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*Geology*

# GENERAL REPORT

ON THE WORK CARRIED ON BY THE

## GEOLOGICAL SURVEY OF INDIA

FOR THE YEAR

1902-1903.

BY

T. H. HOLLAND, A.R.C.S., F.G.S.,

*Director.*



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## ADMINISTRATION LIST.

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### Director.

MR. C. L. GRIESBACH held the office of Director until the 24th February 1903, when he retired and was succeeded by MR. T. H. HOLLAND.

### Superintendents.

1. MR. R. D. OLDHAM, A.R.S.M., F.G.S.
2. MR. T. D. LATOUCHE, B.A., F.G.S., on privilege leave for 28 days from 8th September to 5th October 1902.
3. MR. C. S. MIDDLEMISS, B.A., F.G.S.

### Deputy Superintendents.

1. MR. P. N. BOSE, B.Sc. (Lond.), F.G.S.
2. MR. T. H. HOLLAND, A.R.C.S., F.G.S., returned from combined privilege leave and furlough on the 29th January 1903. Appointed Director from 25th February 1903.
3. MR. P. N. DATTA, B.Sc. (Lond.), F.G.S.
4. MR. F. H. SMITH, A.R.C.S., F.G.S.

### Assistant Superintendents.

1. MR. H. H. HAYDEN, B.A., B.E., F.G.S., promoted to Deputy Superintendent with effect from the 25th February 1903, and vacated office of Curator from the 6th March 1903.
2. MR. E. VREDENBURG, B.L., B.Sc. (Paris), A.R.C.S., appointed Curator of the Geological Museum with effect from the 7th March 1903.
3. MR. L. L. FERMOR, A.R.S.M., F.G.S., joined in India 29th October 1902.
4. MR. G. E. PILGRIM, B.Sc. (Lond.), joined in India 29th October 1902.

### Palaontologist.

1. DR. F. NOETLING, Ph.D. (Berlin), F.G.S.

### Mining Specialists.

1. MR. R. R. SIMPSON, B.Sc., Officiating Inspector of Mines up to 18th December 1902, reverted to his appointment as Coal Specialist on the 20th December 1902.
2. MR. J. M. MACLAREN, B.Sc., F.G.S., joined in India 29th October 1902.

*Sub-Assistants.*

1. HIRA LAL, on privilege leave for 34 days from 1st September 1902.
2. KISHEN SINGH, F.G.S., on sick leave from 27th January 1902.

*Artist.*

1. MR. H. B. W. GARRICK, on privilege leave for 1 month and 4 days from 1st September 1902.

*Assistant Curator.*

1. MR. T. R. BLYTH.

*Registrar.*

1. MR. A. E. MACA. AUDSLEY, on sick leave for 9 months from 7th May 1902.
-

# GENERAL REPORT

ON THE WORK CARRIED ON BY THE

## GEOLOGICAL SURVEY OF INDIA

FOR THE YEAR

### 1902-1903.

---

#### PART I.—HEAD-QUARTER NOTES.

##### I.—Retirement of Mr. C. L. Griesbach.

1. Although this report is written and signed by his successor, eleven-twelfths of the work it reviews was carried out, and the whole of it organized, under the direction of Mr. C. L. Griesbach, C.I.E., whose term of office expired on the 24th February, when he retired under the 55 years' rule.

Mr. Griesbach, in the interests of the work of the Department, has deprived me of the convenient instrument which he himself possessed in the *Records* for reviewing his predecessor's services, when he took over charge of the Department from the late Dr. King in 1894. But whilst attempting to make this report a faithful expression of his last year's work in India, and the final contribution to his record of official activity for over 24 years, I would like to take the opportunity of expressing the hope that in his retirement from the service, but not from geological work, he will receive further signs of the appreciation with which scientific societies in Europe have already marked the work done during his official career in India.

## 2.—Appointments.

2. The gaps in the officers' list caused by the loss of Drs. Walker and von Krafft and Mr. Stonier, referred to in the last General Report (p. 2), have been repaired by the appointment of Messrs. L. L. Fermor, G. E. Pilgrim, and J. M. Maclaren, who arrived in India on the 29th October.

## 3.—Director's Tours.

3. During the year under report, Mr. Griesbach made the following tours:—

In May he visited Shillong to inspect the work carried on by Mr. Bose during the previous field season. During September he visited Kashmir and inspected the localities in which Dr. Noetling had found Gondwana plants associated with permian marine strata (*infra*, p. 22).

Mr. Holland made a tour through the coalfields of Raniganj, Jherria, and Giridih during February.

## 4.—Museum and Laboratory.

4. Mr. H. H. Hayden was in charge as Curator throughout the year, and, in spite of the want of a subordinate staff for work in the galleries, appears to have made satisfactory progress in labelling the collection which has been displayed in the show-cases. The collection of fossils, arranged in zoological order in the wall-cases of the palæontological galleries, were cleaned and re-labelled throughout, and a further portion of the Indian rocks in the lower gallery provided with printed labels.

5. The collection of minerals has been largely augmented by the addition of examples of a number of new and rare species obtained by purchase. As a reference collection the minerals now displayed are worthy of the creditable position which the Indian Museum now admittedly takes amongst the metropolitan museums of the world. The meteorite collection has been enriched by the addition of eight falls not previously represented, bringing the total number of meteorite falls up to 380.

The way in which the Museum is intelligently valued by the public is shown by the complete exhaustion of every edition of the guides which have been prepared by officers of the Geological Survey.

6. Much of the time of the Curator and his Assistant was taken up with the routine determinative and analytical work on specimens sent by other departments and the officers in the field: in this and in the work of the Museum the Curator reports that he has received from the Assistant Curator the same efficient assistance which has characterised every year of Mr. T. R. Blyth's service.

7. The following donations have been received during the year :—

A specimen of galena, from Erki, 20 miles from Simla.

Presented by Capt. Bernard Scott, I.A.

A specimen of asbestos, from near Sejavada, Alirajpur State, Bhopawar Agency, Panch Mahals.

Presented by Balkrishna C. Joshi, Godhra.

Specimens of the Barratta and Gilgoin station aerolites, found in 1845 and 1889, weights 506 grams and 189 grams; and of the Tucson (Arispe) siderite, found in 1850, weight 287 grams.

Presented by Prof. H. A. Ward, Chicago.

A specimen of the Mount Joy siderite, found in 1887, weight 1,240 grams.

Presented by the K. K. Naturhistorisches Hof-Museum, Vienna.

Numerous specimens of bi-pyramidal quartz crystals, from limestone quarries at Katni, Jabalpur district.

Presented by H. F. Cook and Sons, Katni, E. I. Railway.

A specimen of the Bjurböle aerolite, which fell 12th March 1899, weight 27 grams.

Presented by the K. K. Naturhistorisches Hof-Museum, Vienna.

A large specimen of copper pyrites from the Rajdoha Mining Company's "Gladstone" shaft, 233-foot level, Rakka, Chota Nagpur.

Presented by Gillanders Arbuthnot & Co., Calcutta.

## 5.—Palæontological Work.

### (a) DESCRIPTIVE WORK IN INDIA.

8. The progress in descriptive palæontology at head-quarters has been interrupted by the absence of the Palæontologist in the Simla district and Kashmir from April to October and in the Salt Range of the Punjab from November to March.

9. During the last recess, however, Mr. E. Vredenburg undertook the preparation of a catalogue of the Tertiary *Foraminifera* from

Sind and Baluchistan, paying special attention to the *Nummulites*, which are, on account of the way these peculiar forms became spread all over the great central ocean, stretching from Europe to South Asia in early Tertiary times, of unusual assistance in correlating the Lower Tertiaries of Sind and Baluchistan with those of the standard scale of Europe. Taking eight of the more important species which are common to Europe and India, we have the following correlation scale for the Nummulitic formations in the Sind-Baluchistan area :—

*Correlation of Nummulite-bearing beds of Western India.*

Sind and Baluchistan.	European Stages.
LOWER NARI with <i>N. intermedia</i> . . . . .	Priabonian.
Unconformity . . . . .	Bartonian.
UPPER KHIRTHAR (with the Ghazij and Spintangi of Baluchistan) containing <i>N. perforata</i> , <i>N. (Assilina) granulosa</i> , <i>N. (Ass.) exponens</i> . . . . .	Lutetian.
LOWER KHIRTHAR with <i>N. biarritezensis</i> and <i>N. (Assilina) placentula</i> . . . . .	
Unconformity . . . . .	
UPPER RANIKOT—	
Zone 4 with <i>N. planulata</i> and <i>N. (Assilina) cf. nili</i> . . . . .	Ypresian and Sparnacian.
Zone 3 with <i>N. (Assilina) cf. nili</i> . . . . .	
Zone 2 } without Nummulites . . . . .	
Zone 1 }	

## (b) DESCRIPTIVE WORK IN EUROPE.

10. Of the palæontological work done in Europe the only results received during the year are embodied in an important memoir by Prof. Carl Diener, giving a description of the permian fossils collected in the Central Himalayas by Messrs. LaTouche, Smith, Hayden, Walker, and von Krafft during 1898—1900. The memoir, amounting to 214 pages of the *Palæontologia Indica*, is now in the press. The additional details made available by this exhaustive work tend to accentuate the distinction in facies between the normal permian rocks of the Central Himalayas and the permian blocks which have been brought from some unknown region, and left as isolated crags on the younger strata. The permian fossils in these exotic blocks show greater affinities with the Salt Range permian than with the strata of the same age in the Central Himalayas.

## 6.—Publications and Library.

## 11. The following publications were issued during the year:—

General Report on the work carried on by the Geological Survey of India, from the 1st April 1901 to the 31st March 1902.

Memoirs, Volume XXXII, Part 3. Notes on the "Exotic Blocks" of Malla Johar in the Bhot Mahals of Kumaon, by A. von Krafft.

Memoirs, Volume XXXIII, Part 2. Title-page, contents, etc.

Memoirs, Volume XXXIII, Part 3. The Geology of Kalahandi State, Central Provinces, by T. L. Walker.

Memoirs, Volume XXXIV, Part 2. The Mica Deposits of India, by Thomas H. Holland.

Memoirs, Volume XXXV, Part 1. Geology of Western Rajputana, by Tom D. LaTouche.

*Palæontologia Indica*, Series XVI, Volume I. Title-page, contents, etc.

*Palæontologia Indica*, New Series, Volume II, Article 1. Observations sur quelques plantes fossiles des Lower Gondwanas, par R. Zeiller.

The additions to the Library during the year 1902-03 amounted to  
*Library.* 2,017 volumes, of which 1,184 were acquired by  
 presentation and 833 by purchase.

## 7.—Disposition List.

12. During the year ending the 31st March the officers of the Department were posted as follows :—

## SUPERINTENDENTS.

Mr. R. D. Oldham . . .	At head-quarters till November 11th; posted to Upper Burma, Lower Chindwin and Pakoko districts. Returned to head-quarters February 3rd, and left for Jammu March 21st.
Mr. T. H. D. LaTouche . .	Returned to head-quarters from the Northern Shan States on the 20th May 1902. On privilege leave from 8th September to 5th October 1902. Deputed to examine the Ladda coal-field, and returned to head-quarters on the 8th November 1902. Posted to Burma from the 11th November 1902, and returned to head-quarters on the 20th March 1903.
Mr. C. S. Middlemiss . . .	Returned to head-quarters from the Vizagapatam hill tracts on the 10th May 1902. Posted to the same area from the 1st November 1902 to date.

## DEPUTY SUPERINTENDENTS.

Mr. P. N. Bose . . . . .	Returned to head-quarters from Assam on the 11th June 1902; and left Calcutta for the field on the 22nd October 1902 to continue his survey of the Jaintia hills of Assam.
Mr. P. N. Datta . . . . .	Returned from the Northern Shan States on the 26th May 1902. Posted to the same area, and left for the field on the 4th November 1902.
Mr. F. H. Smith . . . . .	Returned to head-quarters from Chota Nagpur on the 3rd May 1902. Posted to the same area on the 5th November 1902.
Mr. H. H. Hayden . . . . .	At head-quarters throughout the year.

## ASSISTANT SUPERINTENDENTS.

Mr. E. Vredenburg . . .	Returned from Baluchistan on the 10th June 1902. Left on 3rd November to make a survey of the Dhar State.
Mr. L. L. Fermor . . .	Joined the Department 29th October 1902. Deputed to accompany Mr. Vredenburg on the 3rd November 1902.
Mr. G. E. Pilgrim . . .	Joined the Department 29th October 1902. Deputed to accompany Mr. LaTouche on the 11th November 1902.

## PALÆONTOLOGIST.

Dr. F. Noetling . . .	Deputed to the Dargoti State, north-east of Simla, on the 22nd April 1902. On completion of this special examination, was posted to Kashmir. Returned to head-quarters on the 23rd October 1902, and left on the 3rd November to accompany Professor E. Koken during his visit to the Salt Range and Siwaliks, and returned to head-quarters on the 5th March 1903.
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## SPECIALISTS.

Mr. R. R. Simpson . . .	Deputed to examine the coal of the Trans-Indus range, Mianwali district, also to the Jammu territory, and left on the 14th January 1903.
Mr. J. M. Maclaren . . .	Joined the Department 29th October 1902. Posted to Chota Nagpur and left Calcutta for the field on the 7th November 1902.

## SUB-ASSISTANT.

Hira Lal . . . . .	During the field season 1902-03. was attached to Mr. Smith's party in the Chota Nagpur division.
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## ASSISTANT CURATOR.

Mr. T. R. Blyth . . . . .	Was on duty at head-quarters throughout the year.
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## PART II.—FIELD-WORK.

## A.—ECONOMIC ENQUIRIES.

## I.—Coal.

13. Towards the close of the season 1901-1902, and after the submission of the report covering the work up to the 31st March, Mr. Bose discovered some rolled fragments of coal in a stream about 4 miles west of Barapani, near Shillong. On resuming field work this season, he followed up this discovery, and successfully traced the origin of the coal to some outcrops situated close to the head-waters of a stream known as the Um Rileng at the foot of Dinghie hill, about 2 miles west of the Shillong-Gauhati cart-road. The outcrops are much concealed by jungle and superficial deposits, but a systematic search and prospecting operations laid bare a fairly good section, in which several horizons of good coal were found, the most important seams of which are two of 4 feet and 6 feet 6 inches thickness, respectively.

14. Assays of two samples made in the Laboratory showed the coal to be of good quality, and its position—within 11 miles of Shillong and only 2 miles from the Shillong-Gauhati cart-road—warranted the institution of a careful exploration of the field. The work of testing the resources of the field was undertaken by the Public Works Department with the assistance of advice from Mr. Bose. Two pits, put down at selected distances from the outcrop, in the hope of meeting the seams and thus proving the horizontal extension of the coal, reached, respectively, 28 and 21 feet, when difficulties arose from the influx of water, and it was decided to continue the test by boring. Matters were at this inconclusive stage at the close of the season, and an attempt will, I hope, be made to carry out the work more energetically during the present year.

15. During January Mr. Simpson undertook the examination of the coal deposits in the Isakhel tahsil of Mianwali district, Punjab. Four groups of deposits were examined, which may be distinguished as—

- (1) Kálabágh area.
- (2) Kuch area.
- (3) Between Kuch and Sagruto summit.
- (4) Mulla Khel and Sultan Khel area.

16. The Kálábágh coal deposits were found to be very variable in quality and thickness of workable seams, and the estimate of about 50,000 tons of available fuel is based on the assumption that an average thickness of 4 feet would be maintained over the strike of 550 feet. At Kuch, about 6 miles further north and less favourably situated for transport to the Indus, a rough estimate was made of 11,000 tons of available coal for a seam averaging about 16 inches in thickness. The coal-seams opened by drives in the ground between Kuch and the Sagruto peak are not considered to be worth working.

17. A more promising result was obtained in the fourth area examined. From the outcrop seen in the Barochi gorge about 2 miles north of Mulla Khel, a seam, varying from 1 to 4 feet in thickness, was traced for about 6 miles to the south to a point west of Sultan Khel. Samples taken from this seam, and from the three other areas, are now being examined in the Laboratory, and when the assays are complete a report will be submitted on the probable value of, and best method of attacking, these deposits.

## 2.—Chromite.

18. In April 1902 Mr. Vredenburg proceeded from Sind to Baluchistan and examined the chrome-iron ore deposits in the Pishin and Zhob districts. The chromite occurs as veins and irregular, segregated masses

BALUCHISTAN :  
*Mr. E. Vredenburg.*

in the serpentines that accompany the great basic intrusions of upper cretaceous age, which form particularly conspicuous masses amongst the hills bordering the Upper Zhob valley, both to the north and south. To the westward these serpentines continue into the upper valley of the Pishin river, which forms the geographical and geological continuation of the Upper Zhob, while to the east and north-east a few observations made at different times by various geologists indicate their continuation at intervals along the Lower Zhob, and even as far as the Tochi valley.

19. One of the most promising localities occurs about 2 miles east of Khánozai in the Pishin district, where Mr. Vredenburg specially investigated a vein-like mass about 400 feet long with an average breadth of 5 feet. The vein consists of almost pure ore of great richness. An analysis made in the Laboratory of the Geological Survey gave over 54 per cent. of chromium sesquioxide, and some parts of the vein show even a higher percentage. The locality is connected by an excellent road with Khanai railway station, 17 miles distant.

### 3.—Fire-clay.

20. The fire-clay previously noticed by Mr. Bose near Jowai was, at the request of the Honourable the Chief Commissioner of Assam, re-examined and sampled for testing. The tests, kindly made by Messrs.

ASSAM :  
*Mr. P. N. Bose.*

Burn & Co., show that the material forms excellent fire-bricks capable of standing a great heat. Its occurrence in large quantity in the vicinity of good coal makes it available for the manufacture of bricks, against which there appears to be only the cost of transport to a market.

### 4.—Gold.

21. On account of the numerous statements which have been made in the past about finds of gold, and of the occurrence of ancient gold-workings in Chota Nagpur, a survey of the most prominent parts of the division was instituted in the season 1901-

CHOTA NAGPUR :  
*Mr. F. H. Smith.*  
*Mr. J. M. Maclaren.*  
*Hira Lal.*

1902 by Mr. Smith and Hira Lal, and was continued during the past season with the addition of Mr. J. Malcolm Maclaren to the party. The details of these investigations will be published in a special memoir now being prepared by Mr. Maclaren.

22. The area examined covers parts of the districts of Mánbhúm and Singhbhúm, with the tributary states of Gangpur, Bonai, Údepúr, and Jashpúr. The distribution of the geological formations, as corrected up to date, is shown in the accompanying map (fig. 1). The large area marked as Dharwarian consists of a group of imperfectly foliated schists and phyllites, similar in general characters to the Dharwar series in South India, and, like them, much older than the oldest unfossiliferous rocks distinguished as the Cuddapahs. A prominent and important feature in the country is the great Dulma band of dioritic trap which runs from south of Dhadka, in Mánbhúm, into Western Singhbhúm, has affected all the rocks in its neighbourhood, and appears to be responsible for the auriferous character of the quartz veins, as all the instances of gold found *in situ*, have been in close proximity to the Dulma trap, or to dykes of a similar petrological character. The most conspicuously auriferous horizon in the Dharwar series is a little south of the Dulma trap-band, just outside the zone of pronounced thermal metamorphism, and, judging by the distribution of alluvial gold at Patkum and in Mánbhúm, a similar auriferous

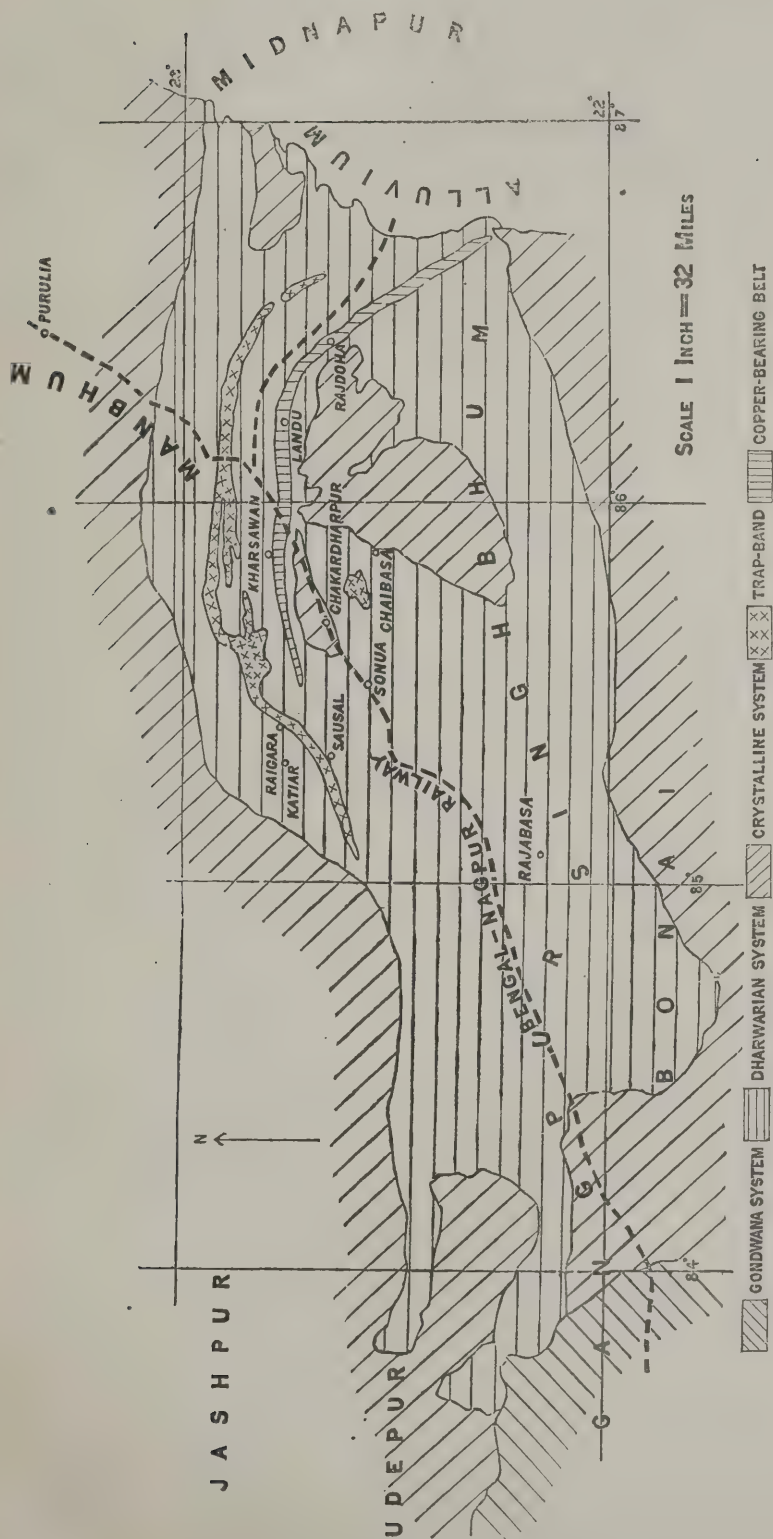


FIG. 1.—Geological Map of the Chota Nagpur auriferous belt.

horizon exists to the north of the trap. The well-known copper-bearing zone, shown on the map further south, was not subjected to special study, the work being confined to testing the resources of the country in gold.

23. Gold being a metal of very wide distribution and one which can be profitably worked in rocks carrying such small quantities, one is never safe in assuming from a few scattered observations that it certainly does not exist in payable quantities in any area of crystalline rocks. In the case of Chota Nagpur, without asserting that payable gold deposits do not *possibly* exist, the results of the present enquiry have not included a single instance which could be reasonably regarded as a legitimate mining proposition.

24. With regard to the quartz reefs, the deposits are thin and their mineral contents "patchy," so much so, that *Auriferous reefs.* instead of expressing the richness in ounces per ton, the ore bodies are so small that they might more appropriately be expressed as grains to the ounce of quartz. The full report will show that the operations conducted by the survey party did not extend to any depth. But the common fallacy that an auriferous vein necessarily improves with depth has not been allowed to divert the party from the policy of making superficial examination of many outcrops instead of deeply prospecting a few.

25. In the course of the survey, two doubtful prospecting propositions were discovered, that is, two areas where, on commercial principles, further search for auriferous veins may be regarded as a justifiable venture. These are (1) the range between Ankva and Manharpur, and (2) the line lying about 3 miles south of the Dulma trap, connecting Sausal and Sonapet. The first is mentioned on account of the rich, coarse, alluvial gold found in the immediate vicinity, of the rich specimen of auriferous quartz picked up in the Ankua stream, and of the existence of large, well-defined quartz reefs in the neighbourhood. Along the second area nearly all of the gold hitherto found *in situ* in this division has been obtained.

26. The recovery of gold from alluvial deposits offers no brighter prospects than that of mining the quartz-veins. *Alluvial gold.* Hydraulic mining, as practised in other countries, is out of the question, on account of lack of water and the poverty of gold content. At Sonapet conditions for the storage of water on a large scale, and under sufficient head, are extremely favourable; but the result of trials indicated the average gold content to be less than  $1\frac{1}{2}$  grains per cubic yard; and, considering the large capital outlay

necessary, this amount is far too small to give any hope of profitable return. At Ankua, also, water could be obtained at no great cost, but the gold content here is only about  $\frac{1}{2}$  grain to the cubic yard—even lower than that of Sonapet. It has been suggested that the richer gravels, at least, could be shifted at a profit to suitably situated tail-races by coolie labour, but, though this may be possible for dry gravel, the handling of gravel full of water would hopelessly handicap the undertaking.

27. The suggestion to undertake dredging operations has also been kept in view; but the conditions of the Chota Nagpur rivers introduce difficulties not usually encountered in successful dredging operations. Most of the rivers flow over the hard, upturned edges of schistose rocks, which, as in the Súbanríkha, form a succession of rocky bars across the stream, between which native workers wash for gold. Operations would necessarily be intermittent on account of the annual floods, and with each flood the layer of "wash" stripped would be covered with several feet of fresh *débris*. The layers of gravel, not more than 3 to 6 inches thick, in which the gold is stored, rarely contain more than a grain of gold to the cubic yard.

28. There is one possible exception to this general condemnation. In the Brahmini river, near Durjing in Bonai, the alluvial flat would, if the gold content were sufficient, make an ideal "pond-dredging" proposition; but the tests made show a content of less than one grain to the cubic yard, which would be insufficient for profitable work.

29. To what extent this general conclusion is justified by the observations made, the expert will be able to judge on publication of the details; but it should be understood that the operations which have been conducted have not exhausted the *possibilities* of the area. Gold is undoubtedly widely distributed—indeed, almost universal—in the country examined, and future explorations *may* possibly reveal an instance of local concentration in payable quantities. But the results so far obtained, of a fairly conducted exploration, are sufficient to show that, in the absence of such definite evidence, gold-prospecting in this area could not, except in the possible instances named, be honestly recommended as a reasonable venture.

30. Whilst there are not wanting evidences of the persistent search for gold in Chota Nagpur during the past, there are no signs of extensive and deep ancient workings, such as are known in the auriferous tracts of South India. The general distribution of the metal evidently attracted numbers of native workers in the past, but there is no striking instance to show that their efforts were maintained for long in any

one place, and this interpretation of their results is in agreement with the conclusions of the survey just made.

### 5.—Iron and Manganese.

31. Amongst the questions of economic importance taken up during the survey of the Dhar forest, the rich iron-ores which form fault-breccias received some attention. They follow lines of faulting, the richest hematitic deposits being found along the great fault which Dr. W. T. Blanford long ago recognised as separating the Vindhyan and Bijawar systems throughout the entire district from east to west. The main, and at present insuperable, difficulty in connection with the development of these ores on a large scale is the absence of mineral fuel.

DHAR:  
*Mr. E. Vredenburg.*  
*Mr. L. L. Fermor.*

32. Manganese ores are widely distributed as a cementing material in the coarse conglomerate at the base of the Lameta series. These and some other minerals of possible value are now being analysed in the Laboratory, and will be reported in detail to the Dhar Durbar.

### 6.—Lead.

33. Dr. Noetling was deputed in April to the Dargoti State, north-east of Simla, to report on a lode of galena, regarded by the State officials as possibly valuable. His observations, supported by the assays made by the Curator, showed that the ore-body is neither rich enough nor large enough for successful exploitation.

DARGOTI:  
*Dr. F. Noetling.*

### 7.—Petroleum.

34. During January Mr. Oldham examined the area covered by the newly delimited blocks extending northwards from the ground described by the late Mr. G. E. Grimes<sup>1</sup> in the Pakoku district. The absence of topographical details on the maps prevented the preparation of a detailed geological map; but, by obtaining the positions of the boundary pillars, Mr. Oldham has succeeded in tracing the course of the anticline running northwards from the Yenangyat oil-field.

35. Throughout most of its course Prome beds are exposed in the axis of the anticline. The first oil-sand is exposed in the Ngapok-

BURMA:  
*Mr. R. D. Oldham.*

<sup>1</sup> Mem. Geol. Surv. Ind., vol. XXVIII, pt. 1.

choung in block 48 ; the first four in block 57 and the first five in block 67, after which, on going north, the axis of the anticline pitches rapidly to the north, and the exposure of Prome beds dies out completely in block 123. The structure is that of a productive oil-field, and it is possible that a remunerative supply of oil could be obtained ; but the free exposure of the upper oil-sands must have led to the escape of large quantities, and the absence of cover, owing to exposure of the Prome beds, will prevent the development of pressure which gives rise to the flowing wells of Yenangyat. At the same time, although the known oil-sands may be less productive than at Yenangyat, lower beds are made more accessible for exploration by the rise of the anticlinal axis, and the possibility of the occurrence of lower oil-sands may thus be tested by boring.

### 8.—Water.

36. During May Mr. Vredenburg was engaged in examining certain localities in the neighbourhood of Quetta to ascertain the possibility of obtaining a supply of artesian water, and points were selected where boring tests will be undertaken by the Local Government.

BALUCHISTAN :  
*Mr. E. Vredenburg.*

37. During the survey of the Dhar forest attention was given to the question of water-supply, as the Nimanpur pargana is unfavourably situated in this respect. Nearly the whole of the pargana is in the condition of a terrace situated at an altitude intermediate between that of the deep Narbada valley to the south and the much loftier Malwa plateau to the north. The flatness of this terrace is remarkable, and is explained by its representing an ancient cretaceous peneplain of hard Bijawar and Vindhyan rocks, once more brought to light owing to the denudation of the easily-weathered, overlying Lameta rocks. From the foot of the Malwa scarp to the edge of the cliffs that overlook the Narbada, the level of this land remains almost everywhere the same, generally a little under 900 feet. Water-courses are scarce, and develop into gorges which gradually become deeper as they approach the Narbada. In many cases the stream-beds get lost in "swallow-holes," and the whole plateau is thus drained so effectively, that it is very difficult to obtain any water during the driest part of the year, notwithstanding the fairly abundant rainfall. This circumstance, together with the natural aridity of much of the Bijawar and Vindhyan outcrops, accounts for the region having never been occupied by a

DHAR :  
*Mr. E. Vredenburg.*

strictly agricultural population, and since the abandonment of the iron mines, consequent on the importation of cheaper foreign metal, the district has been practically deserted. The physical conditions are the very opposite of those required for artesian wells. Nearly all the shallow wells fed by the surface water become dry during a part of the year, while the sinking of deep wells is too costly and too uncertain to be recommended. Hence in those parts of the plateau where patches of cultivable land exist (usually in connection with Lameta outliers), all efforts should be restricted to surface works, such as the construction of dams, and perhaps of small canals.

38. These remarks do not apply to the strip of land in the northern part of the pargana, along the foot of the Malwa scarp, where water usually exists at a small depth, and where the weathering of the basalt produces "black soil" of great richness.

#### B.—GEOLOGICAL SURVEYS.

##### 1.—Assam.

39. Mr. Bose continued his survey of the Khasia and Jaintia hills in Assam, extending the work on the one-inch scale over parts of Sheets 29, 30, 42, 43, and 44, and thus reducing by another 500 square miles the ground left unsurveyed.

40. The accepted relationships of the formations mentioned in the two previous General Reports (1900-1901, p. 20, and 1901-1902, p. 25) have not been modified by this work. But a small coal-bearing formation, near the head-waters of the Um Rileng, 11 miles north of Shillong, discovered since the submission of the last Report, and at first announced, on account of the peculiar character of its coal, as cretaceous, is now doubtfully given a post-tertiary age by Mr. Bose. He has found, on tracing the rocks further westward into the valley of the Kakri river, within a short distance of Laidom, where the cretaceous rocks are typically developed, that the lithological dissimilarity between the new beds and the cretaceous is so great that he now doubts his original correlation. On account of the imperfectly consolidated character of the Um Rileng beds, he is inclined to regard them as comparatively recent in age. But the form of evidence is admittedly weak, and as there are signs of considerable changes in the physical features of the area since the deposition of the Um Rileng beds, the age of the formation must remain, in the absence of fossils, undetermined. The attempts

made to test the value of the coal-seams have been reviewed on a previous page (p. 8).

## 2.—Baluchistan.

41. The long-controverted question as to the age of the Takatu mountain near Quetta has now been definitely settled. Some years ago Mr. F. H. Smith made a carefully detailed survey of the ranges, from which it became evident that the massive limestone, forming the main line of peaks, with a scarped face to the south-east and a dip-slope to the north-west, does not really overlies the cretaceous rocks of the lower ranges to the south-east, but has been brought into its place by an overthrust fault. The opinion as to its eocene age upheld for many years by previous observers could no longer, therefore, be maintained. Some fossils showing mesozoic affinities were also found, but not sufficiently characteristic for a more precise determination of the age. Following Mr. Smith's indications, Mr. Vredenburg came across several localities where the fossils are more plentiful, the most abundant of all belonging to two species of *Spiriferina*. These fossils occur in a thick series of shales and flaggy limestones, extensively developed in several parts of Baluchistan, and of an age which cannot be later than liassic. In normal sections they always underlie the great formation appropriately named by Mr. Oldham the "massive limestone," in whose uppermost strata callovian fossils have been described by Dr. Noetling.<sup>1</sup> It is the latter rock, and not the Nummulitic eocene limestone, that forms the most conspicuous portion of the Takatu.

## 3.—Burma.

42. During the course of his work in the Lower Chindwin district, Mr. Oldham paid special attention to the peculiar, crater-like hollows occurring in the tertiary rocks. These hollows have precipitous sides, and are sometimes a mile or more in diameter, occasionally including small lakes of salt water; in one case near Laske, there were three confluent hollows, with low cross-ridges of volcanic ash between them, making a depression  $1\frac{1}{2}$  miles long, and reaching, in the centre and deepest hollow, 150 feet below the general surface of the country. The fragmentary materials in the country around include fragments of andesitic lava, mixed with blocks derived from the tertiary

EXPLOSION CRATERS,  
LOWER CHINDWIN  
DISTRICT:  
Mr. R. D. Oldham.

<sup>1</sup> Pal. Ind., ser. XVI, vol. I, pt. 1.

beds; but unmistakable volcanic tuffs are found near by, lying on the pliocene sandstones, the original shapes of the accumulations having been modified by recent erosion. There are eleven of these curious pit-craters in the district, arranged along a line running about N.-E.—S.-W. for a distance of 13 miles, thus suggesting their connection with some tectonic fissure, which, however, has not been otherwise suspected or proved. They were evidently formed after the cessation of the normal volcanic activity known to have occurred in the area, and were produced, according to Mr. Oldham's judgment on the facts, by sudden and violent explosions of gases, not followed by ordinary volcanic ejection, but beginning and ending abruptly. It is interesting to note that the volcanic material of the neighbourhood is andesitic in its character, as the most violent of explosive eruptions have been those connected with andesitic material, the recent eruptions in the West Indies having added further instances. The full paper will be published in the *Records*, which are to be revived.

43. The work which has been done in the Northern Shan States by Messrs. LaTouche, Datta, and Pilgrim, requires

NORTHERN SHAN  
STATES:

*Mr. T. D. LaTouche.*  
*Mr. P. N. Datta.*  
*Mr. G. E. Pilgrim.*

either a detailed explanation on account of the difficulties which have arisen, or a brief mention on account of the few indisputable conclusions which have been obtained with regard to the

stratigraphical characters of the country. The difficulties, treated at considerable length in the reports for 1899-1900 and 1900-1901, are not yet removed, and the conclusions, stated more precisely in 1901-1902, have yet to be substantiated by palæontological work. The collections of fossils made during the past four seasons have now been sent to England for critical examination, and until they are accurately determined, the questions of correlation of the systems in Upper Burma with those on the European standard scale must be kept in abeyance.

44. The premature discussion, however, of the question of correlation has regretfully obscured the actual observations, and has retarded the work of mapping the local natural groups of strata, which should be recognised and mapped as the first duty of the survey, apart from the interesting question of equivalence with the recognised systems of Europe. No system of strata in India is coeval, beginning and finish, with any one in Europe, and the use of European terms should follow, not guide, the work of outlining formations on our maps. Whether a system of strata is palæozoic or mesozoic the essential

characters which give it an individuality as a system should be delineated and mapped, and that work will represent so much positive progress whether its exact age can be determined or not.

45. In spite, however, of the confusion and the time which has been wasted over purely academic questions, the detailed lithological and stratigraphical description of the country has forced a recognition of certain of the groups with pronounced individuality, and the work which has been done in mapping, describing, and collecting from these represents solid and satisfactory progress. The formations about which there is no possible doubt have been outlined, and large collections of fossils have been made.

46. Mr. LaTouche has covered the new sheets, Nos. 239—241, published since the last report, and has completed the work partially done during the previous season on Sheets 285—287. He has also made a traverse through the Ruby Mines district, and, as far as the thick jungle would permit, has mapped the courses of several bands of the crystalline limestones in which the ruby is found. The details will be published when the survey has been completed; meanwhile, Mr. LaTouche, who is now on furlough, has taken the opportunity of obtaining the opinions of specialists at home on the fossils which have been collected, and will endeavour to arrange for their description in Europe in the hope of being able to supplement the field observations with palæontological data sufficiently precise to permit of correlation.

47. Mr. Datta has similarly extended the survey work to the east and south, completing Sheets 332 and 333, and covering parts of 331, 379, and 380.

#### 4.—Central India.

48. Mr. Vredenburg's services were lent for the field season to the Dhar Durbar, and, with the assistance of  
 DHAR FOREST:  
*Mr. E. Vredenburg.*  
*Mr. L. L. Fermor.*  
 Mr. Fermor, he made a detailed survey of the Nimanpur pargana, generally known as the Dhar forest. The observations made on minerals of economic value are noticed separately (pp. 14 and 15), but in addition to these some questions of geological interest have been developed and settled. As an example of the three-fold work of the geological surveyor—the delineation of formations on the map, the application of newly-discovered phenomena to current geological problems, and the recognition of possible occurrences of material valuable from an economic stand-point—Mr. Vredenburg's work in this area merits the highest degree of commendation.

49. The most important amongst the questions which can fairly be regarded as now settled, is the age of the sandstones and conglomerates, formerly regarded by Mr. J. G. Medlicott and Dr. W. T. Blanford as part of the Lameta series of rocks which were deposited on the old Gondwana continent before it was overwhelmed by the great flows of Deccan trap in uppermost cretaceous times.

Later writers on the area came to the conclusion that some exposures of the sandstones regarded as Lameta probably belonged to the Gondwana system, and hopes were consequently entertained of finding coal in this area. The formation is fairly constant in consisting of an upper division, in which the prevailing sandstones are associated with shales and calcareous beds, resting on a lower division of conglomerate



FIG. 2.—*Geological map of the Dhar Forest.*

of well-rounded pebbles, embedded in clay or loose sand, or cemented by calcite, oxides of iron, or manganese. Throughout the greater portion of the area examined during the season this formation is unfossiliferous; but at the south-western extremity of the map (fig. 2), near Barwaha in Holkar territory, the conglomerate contains typical Bâgh (cretaceous) fossils. The fossiliferous conglomerate is lithologically identical with that which everywhere else in the area underlies the supposed Gondwana sandstone, and here also actually underlies the sandstone previously regarded as Gondwana. It is quite clear, therefore, that Dr. Blanford's original correlation of these beds with the Lametas was correct. His conclusions, based on lithological similarities, have now been confirmed by observed continuity of the sandstone and conglomerate without fossils to the sandstone and conglomerate with unmistakable cretaceous forms.

50. It follows also from these observations that the Lameta and the Bâgh series are of the same age, the former being the deposits laid down in fresh water on the Gondwana continent, whilst the latter are those formed at the same time in the adjoining sea. The Barwaha exposure

thus indicates approximately the easternmost limit of trespass by the cretaceous (cenomanian) sea.

51. In another way this work has been interesting as a contribution to the physical geography of the old land area which was overwhelmed by the great Deccan lava-flows in uppermost cretaceous times. In places where atmospheric agents have cut through the protecting envelope of trap, the old weathered surfaces of the Lameta series have been exposed, showing ferruginous and manganiiferous laterites, like those of modern times, and revealing the old irregularities of surface due to river action in cretaceous times. The filling-up by the lava-flows of the old ravines cut in the Lameta sandstones has led some previous observers to false conclusions with regard to the relative ages of some exposures of Lameta sandstone and adjoining trap. Near Chandgarh, for instance, where the Narbada cuts through a thick conglomeratic bed, the latter, on account of its high level, was formerly taken to be a sub-recent accumulation in the river valley; but Mr. Fermor, who crossed the exposure early in the season, was struck by the absence of basalt and agate pebbles amongst the boulders, as one would expect in a conglomerate formed at the expense of the Deccan trap. On returning later on, in accordance with Mr. Vredenburg's instructions, to examine the exposure more critically, it was found that the apparent higher position of the conglomerate was due to the Deccan trap having filled-in a deep valley in the Lameta beds.<sup>1</sup>

52. Observations which give us glimpses of the old cretaceous landscape which was obliterated by the great lava-flows do more than satisfy geological curiosity. The Deccan trap has protected the mineral wealth of the continent for over 200,000 square miles, and it probably hides more coal than that which has escaped the uninterrupted ravages of the weather in the parts of the country exposed throughout the subsequent tertiary era. The valuable seams of coal, for instance, accidentally exposed by the notch cut out of the trap in the Pench valley in the Central Provinces gives an indication of what is still hidden below.

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<sup>1</sup> The recognition of a cretaceous age for these beds formerly regarded as sub-recent, leads us to suspect that the same may be true of similar deposits in other parts of India, for instance, those in which are situated the so-called alluvial diamond-workings of Bundelkhand. There are many features in connection with these deposits which confirm the suspicion that they are not recent alluvial deposits, but are probably lately uncovered patches of the Lameta series, and this conclusion, if established, will have an important bearing on prospecting operations in Central India.

## 5.—Kashmir.

53. Dr. Noetling was deputed to Kashmir in May to enquire into the relations of the permo-triassic rocks to those

*Dr. F. Noetling.*

which, in the Salt Range and in the Central Himalayas of Spiti and Kumaon, have proved to be of such great interest to palæontologists. Amongst the results of Dr. Noetling's work, the discovery of the fossil ferns, *Gangamopteris* and *Glossopteris*, in beds apparently below permian marine strata has an important bearing on the geological age of the Lower Gondwana beds in Peninsular India—a question on which the Geological Survey of India had for many years to stand alone, and without the support of its own palæontologist. Whilst the upper limit of the Gondwana system in Peninsular India could be defined with precision as upper jurassic, on account of the trespass of the sea and the deposition of characteristic marine fossils in beds containing Upper Gondwana forms, there remained the great thickness of beds below in the Peninsula with fossil plants, amongst which *Glossopteris* and *Gangamopteris*, occurring in the lowest stages, indicated (according to the European key to the palæontological cipher) a jurassic age also. Relying on the accuracy of their stratigraphical work, the Geological Survey, led in this question by Dr. W. T. Blanford, insisted on the greater age of the Lower Gondwana rocks, and on purely indirect evidence fixed the base of the great system, in spite of the testimony of the *Glossopteris* flora, as approximately equivalent to the permian of Europe. Turning around to question the validity of the doctrines by which the Lower Gondwanas were considered to be jurassic on account of their fossil plants, the Geological Survey added to the strength of Professor Huxley's contention that evolution amongst the inhabitants of isolated land-areas proceeds at dissimilar rates, in contrast to the greater uniformity in the distribution of marine forms; and that, instead of the Lower Gondwanas being jurassic in age, the evidence pointed to the existence in India (and in Australia, Africa, and South America, where similar rocks occurred) of *Glossopteris* and its relatives several geological ages before these forms made their appearance in Europe and in northern lands generally.

54. The position taken up finally became strong enough—strengthened, in fact, by much, and often bitter, controversy—to force conviction on the geologists at home; but still direct and positive

proof remained wanting. Now, however, if Dr. Noetling has correctly read the facts recorded in Kashmir, the final point has been established by direct evidence. The discovery is sufficiently important to merit an immediate record of the essential details.

55. At Khunmu, in the Vihi valley, 15 miles south-east of Srinagar, a series of volcanic beds are covered in order by beds of quartzitic sandstones and unfossiliferous limestones, on which shales containing remains of *Gangamopteris* were found, followed conformably by chert beds, and a calcareous shale with further remains of *Gangamopteris*, associated with a ganoid fish of permian affinities, and fragments of a skull of *Archegosaurus*. There is then a break in the observations, due to the slopes being covered by talus deposits, and the next beds exposed, dipping in the same direction, and presumably following the plant-bearing bed without a break, contain *Fenestella* with other *Bryozoa*. The *Fenestella* beds are covered by limestones with *Spirifer derbyi*, *Productus indicus*, and other well-known Salt Range fossils, which conclusively prove the permian age of the beds.

56. Accepting Dr. Noetling's opinion that the gap in the exposures could not possibly hide a fault (which might have brought the permian limestones into their apparent position above the plant-bearing beds) the section he has described shows by direct evidence from marine fossils, that the *Glossopteris* flora did actually exist in India in permian times. At this distance from the late seventies, when the position of the Geological Survey was so strongly assailed, the discovery produces no further comment than the remark that the plants are just where they ought to be expected. But those who took part in the controversy, and know of the difficulties of trusting to the defence of indirect evidence, will, as many as are still living, receive the announcement of this simple fact with satisfaction. To them, and especially to Dr. Blanford, who has left such a monument of solid work in India, my congratulations are offered in the name of my predecessor, under whom the work was done, and in the name of my colleagues.

## 6.—Madras.

57. The area examined embraces the lower plainward edge and fringe of the 3,000-foot plateau lying to the north and south of the Salur-Jeypore ghât road, and included in Sheet 108 of the Atlas of India (1 inch = 4 miles), as well as the greater part of Sheet 93 S.E., left over

VIZAGAPATAM HILL  
TRACTS:

Mr. C. S. Middlemiss.

from last year. To the above may be added a route traverse across Sheet 93 N.-E., *via* Jeypore, and also a flying visit to the manganese mines of Kodur (Garavidi, on the Bengal Nagpur Railway).

58. The season's work has again resulted in the discovery of nothing but crystalline rocks and the unfossiliferous old strata of probably Cuddapah age. The main groups of the crystalline rocks in the Vizagapatam hill tracts have now been outlined, and except for two small patches, one in the north-east of Vizagapatam district and the other in the south-west on the borders of Godavari district, this blank formerly existing in the geological map of India has been filled in.

59. The rock-groups fall naturally into four main bands, which, with their N.-E.—S.-W. trend, determine the physical contours of the country. The north-western band, lying parallel to and adjoining the Bastar State, is a complex of hornblendic and micaceous gneisses and schists, often containing potstone, quartzites, frequently ferruginous, bands of augen-gneiss, forming the hills, charnockite in small quantity, and younger diabase-dykes. The country composed of these rocks is, generally speaking, a flat plateau, or set of two or more plateaux ascending by steps from 800 feet in the south-west end to over 1,000 feet in the north-east near Jeypore. This plateau bears a thick layer of soil of a bright red colour, through which the unaltered rocks occasionally protrude as isolated hills and on the edges of the ghâts.

60. With a fairly well-marked scarp and rise of about 1,000 feet, the boundary of the next band of rocks is marked off sharply from the first. This band is composed mainly of the charnockite series with associated khondalites, and grades into the third band on its south-east side, where, in addition to the charnockites and khondalites, gneissose granite and granulites make their appearance. These two—the second and third band—together form a rough, hilly country, traversed by flat, open valleys. The khondalites are regarded as originally sedimentary rocks, now completely metamorphosed by the intrusions of charnockite and granite. Amongst the results of contact-action Mr. Middlemiss has cited bands of magnetite, limonite, and manganese ores near the junction of the khondalite series and the igneous masses.

61. The south-eastern edge of the third band forms a well-marked scarp traversed in the usual way by ghâts, as the rapid drop occurs from the 3,000-foot plateau on to the plains to the east. In this low land, forming the fourth band, the rocks are mainly of the khondalite series, through which occasional bosses of gneissose granite and charnockite protrude.

62. The large mass of crystalline rocks thus briefly described contains the usual great variety of lithological types, a few of which, on account of their exceptional characters, deserve special notice. Near Koraput, for instance, Mr. Middlemiss found a band of *elæolite-syenite* gneiss, which is now the second instance of this interesting rock-group in Peninsular India, the first found being that of Sivamalai in the Coimbatore district.<sup>1</sup>

Another rock-band contains so many exceptional minerals that the specimens will require a detailed study for their identification. *Sapphirine*, a prominent constituent of one of these bands, is a mineral which has only been found in one other locality, namely, *Fiskernäs*, in Greenland. This band has been traced for some 30 miles from Guda to Sampangputi, and the study of the large collection of strange types obtained will certainly lead to results of considerable mineralogical interest.

63. Mr. Middlemiss is of opinion that the high-level laterite of these hills is a definite sedimentary deposit laid down in water. It is limited, he reports, to a fairly constant level, surrounding the hills like a shore-belt, through which the bare rocks now rise to superior heights, and were, he thinks, "islands in the lateritic age." On the inward side of the terraces there is, in each case, a shingle deposit of rolled and partly rounded pebbles of the underlying *khondalite* rock, set in a *pisolitic* laterite matrix. But no fossils of any sort have been found. This is an addition to the many theories which have been advanced to account for this peculiar formation, and it can only be discussed with fairness after a full display of the data. Judging, however, by the summary of observations at my disposal, I should not be disposed to regard this new suggestion as one likely to affect the growing conviction that laterite is due to a form of rock-decomposition peculiar to, or at any rate specially prominent in, moist, tropical climates.

### 7.—Punjab.

64. In accordance with instructions from the Right Honourable the Secretary of State, Dr. Noetling was deputed, during the cold weather of 1902-03, to accompany Professor E. Koken of Tübingen on his tour through the Salt Range. Only short notes of the observations made have been submitted by Dr. Noetling, and in these two important conclusions requiring further detailed support have been reported.

SALT RANGE :

*Dr. F. Noetling.*  
*Prof. E. Koken.*

<sup>1</sup> *Memoirs, Geol. Surv. Ind., vol. XXX, pt. 3.*

65. The peculiar salt-marl, lying below the cambrian strata, has been a puzzle to every worker in the Salt Range: the preservation of large masses of salt since pre-cambrian times, as its stratigraphical position appeared to indicate, is without a parallel; and the fact that other salt deposits not far off appeared to be of tertiary age, as well as the abnormal characters of the salt-marl itself, have combined to suggest that its position immediately below lower cambrian beds must have been attained by some process other than normal sedimentation. These points have been noticed by many previous workers, who felt unable to offer a satisfactory explanation of the apparently anomalous phenomena. Dr. Noetling reports now that there are evidences of the whole sedimentary series, from cambrian to tertiary, having been thrust bodily in a southerly direction over the salt-marl, and that the latter is probably but another exposure of the tertiary salt-bearing formation like that represented at Kohat. The idea thus involves an extension of the thrust-plane noticed by Mr. A. B. Wynne many years ago near Kalabagh. There are many questions to answer before accepting this plausible explanation of the difficulty, and it is a subject of sufficient importance to merit more detailed observations than have been reported.

66. The other point of interest is the discovery of further, and apparently conclusive, evidence in support of the theory held by the Department that the Salt Range boulder-bed is due to glacial action in permian times. On the northern slope of the western branch of the Makrach glen, where the boulder-bed has been removed by the weather, typical glacial striæ were found on the cambrian magnesian sandstone, over which the ice must have moved. Evidence was obtained also to show that the facettled boulders, which have been so puzzling to glacialists, must have been planed in their peculiar way by being embedded in the rocks over which the glacier and its ground-moraine moved, a new face being cut when the boulder became shifted and turned over. It is to be regretted that specimens and drawings in illustration of these interesting observations have not been offered to the Department, the only account of the details available being those published in a series of joint papers by Drs. Koken and Noetling in the *Centralblatt für Mineralogie, Geologie und Palæontologie*, 1903.

T. H. HOLLAND, *Director,*  
*Geological Survey of India.*

CALCUTTA;  
August 1st, 1903.





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*Geology*

# GENERAL REPORT

ON THE WORK CARRIED ON BY THE

## GEOLOGICAL SURVEY OF INDIA

FOR THE PERIOD FROM THE 1ST APRIL

1901

TO THE 31ST MARCH

1902.

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- Part 1.*—Annual report for 1876. Geological notes on the Great Indian Desert between Sind and Rajputana. On the occurrence of the cretaceous genus *Omphalia* near Nameho lake, Tibet, about 75 miles north of Lhassa. On *Estheria* in the Gondwana formation. Notices of new and other vertebrata from Indian tertiary and secondary rocks. Description of a new *Emydine* from the upper tertiaries of the Northern Punjab. Observations on under-ground temperature.
- Part 2.*—On the rocks of the Lower Godavari. On the 'Atgarh Sandstones' near Cuttack. On fossil floras in India. Notices of new or rare mammals from the Siwaliks. On the Arvali series in North-eastern Rajputana. Borings for coal in India. On the geology of India.
- Part 3.*—On the tertiary zone and underlying rocks in the North-west Punjab. On fossil floras in India. On the occurrence of erratics in the Potwar. On recent coal explorations in the Darjiling district. Limestones in the neighbourhood of Barakar. On some forms of blowing-machine used by the smiths of Upper Assam. Analyses of Raniganj coals.
- Part 4.*—On the Geology of the Mahanadi basin and its vicinity. On the diamonds, gold, and lead ores of the Sambalpur district. Note on 'Eryon Comp. Barrovensis,' McCoy, from the Sripermatur group near Madras. On fossil floras in India. The Blaini group and the 'Central Gneiss' in the Simla Himalayas. Remarks on some statements in Mr. Wynne's paper on the tertiaries of the North-west Punjab. Note on the genera *Chœromeryx* and *Rhagatherium*.

VOL. XI, 1878.

- Part 1.*—Annual report for 1877. On the geology of the Upper Godavari basin, between the river Wardha and the Godavari, near the civil station of Sironcha. On the geology of Kashmir, Kishtwar, and Pangi. Notices of Siwalik mammals. The palæontological relations of the Gondwana system. On 'Remarks, &c., by Mr. Theobald upon erratics in the Punjab.'
- Part 2.*—On the Geology of Sind (second notice). On the origin of the Kumaun lakes. On a trip over the Milam Pass, Kumaun. The mud volcanoes of Ramri and Cheduba. On the mineral resources of Ramri, Cheduba, and the adjacent islands.

GENERAL REPORT  
ON THE WORK CARRIED ON BY THE  
GEOLOGICAL SURVEY OF INDIA

FOR THE PERIOD FROM THE 1ST APRIL

1901

TO THE 31ST MARCH

1902.

UNDER THE DIRECTION OF

C. L. GRIESBACH, C.I.E., F.G.S.



CALCUTTA :

OFFICE OF THE SUPERINTENDENT, GOVERNMENT PRINTING, INDIA,

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### GEOLOGICAL SURVEY OF INDIA.

DIRECTOR.

C. L. GRIESBACH, C.I.E., F.G.S.

#### SUPERINTENDENTS.

1. R. D. OLDHAM, A.R.S.M., F.G.S., returned from furlough on the 17th July 1901.
2. TOM D. LATOUCHE, B.A., F.G.S., on privilege leave from 11th September to 18th October 1901.
3. C. S. MIDDLEMISS, B.A., F.G.S., returned from furlough on 18th December 1901.

#### DEPUTY SUPERINTENDENTS.

1. P. N. BOSE, B.Sc. (London), F.G.S., on privilege leave from 30th May to 1st July 1901.
2. T. H. HOLLAND, A.R.C.S., F.G.S., also Curator up to 18th March 1901, and Officiating Superintendent *vice* Messrs. Oldham and Middlemiss from 6th July 1899 to 17th December 1901. On combined privilege leave and furlough from 29th October 1901.

23/10/1902

3. P. N. DATTA, B.Sc. (London), F.G.S., also Officiating Superintendent *vice* Mr. Middlemiss from the 7th June 1900 to 16th July 1901. On privilege leave from 14th August to 28th October 1901, and Officiating Superintendent *vice* Mr. Holland from 29th October to 17th December 1901.
4. F. H. Smith, A.R.C.S., returned from furlough on 18th November 1901.

## ASSISTANT SUPERINTENDENTS.

1. H. H. HAYDEN, B.A., B.E., Officiating Deputy Superintendent from 6th July 1899 *vice* Mr. T. H. Holland, also Curator from 19th March 1901 *vice* Mr. T. H. Holland.
2. E. VREDENBURG, B.L., B.Sc. (Paris), A.R.C.S., also Officiating Deputy Superintendent *vice* Messrs. Smith and Middlemiss from 9th May 1900 to 17th December 1901.
3. T. L. WALKER, M.A. (Kingston), Ph. D. (Leipzig), also Officiating Deputy Superintendent *vice* Mr. P. N. Datta from 7th June 1900 to 16th July 1901. On extraordinary leave for 2 months with effect from 29th October 1901. Resigned appointment with effect from 28th December 1901.
4. A. KRAFFT von Dellmensingen, Ph. D. (Vienna), also Officiating Palæontologist *vice* Dr. F. Noetling, from 1st May 1901. Died at Calcutta on the 22nd September 1901.

## PALÆONTOLOGIST.

FRITZ NOETLING, Ph. D. (Berlin), F.G.S. *On privilege leave combined with furlough from 1st May to 29th October 1901.*

## SPECIALISTS.

1. G. A. STONIER, A.R.S.M., F.G.S., also Officiating Inspector of Mines in India *vice* Mr. Grundy from 13th March 1901. Appointed Chief Inspector of Mines in India with effect from 7th January 1902.
2. R. R. Simpson, B.Sc., in Mining (Dunelm), also Officiating Inspector of Mines with effect from the 13th November 1901.

## SUB-ASSISTANTS.

1. HIRALAL.
2. KISHEN SINGH, F.G.S.

## ARTIST.

H. B. W. GARRICK.

## ASSISTANT CURATOR.

T. R. BLYTH. Appointed Assistant Curator from 13th February 1901.

## REGISTRAR.

A. E. MacA. AUDSLEY.

# GENERAL REPORT

## ON THE WORK CARRIED ON BY THE

# GEOLOGICAL SURVEY OF INDIA

FOR THE PERIOD FROM THE 1ST APRIL

1901

TO THE 31ST MARCH

1902.

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### PART I.—HEAD-QUARTER NOTES.

*Director's tours.*

During the year under report, I carried out the following tours:—

- (1) I proceeded to the Punjab and Kashmir, leaving Calcutta on the 7th September and returning on the 17th October, for the purpose of studying the lower trias sections of the Vihi and Scind valleys in greater detail than was done by Mr. Lydekker, who had surveyed Kashmir many years ago. The very important task still remains of correlating the lower trias of Kashmir with that of the Central Himalayas and also the Salt range in the Punjab. It is hoped that these studies will be commenced during the summer months of 1902.  

PUNJAB AND KASHMIR.
- (2) From the 11th November to 8th December I remained in the northern Shan States of Burma for the purpose of inspecting the progress of work carried on by Messrs. LaTouche and Datta,  

UPPER BURMA.

who had completed the survey of a very large tract of country. Some of the points on which these two officers differed in their interpretation were carefully discussed, and as these considerations were mainly based upon fossil evidence, Dr. Noetling, the Palæontologist of the Department, was also deputed to Burma to aid in these revisions.

- (3) During March 1902 I visited Mr. F. H. Smith's party which is engaged in the examination of the auriferous localities in Chota Nag-

CHOTA NAGPORE.

pore. As will be seen further on, the results obtained so far are not very encouraging, but nevertheless this inquiry will have to be carried on until at least all the localities which had once upon a time been either prospected or worked for useful minerals have been subjected to a thorough examination.

During the year under report the Department lost the services of four officers: two geologists on the regular staff, and two mining specialists. Dr. von Krafft died suddenly on the 22nd September 1901, but not without leaving behind him valuable reports and manuscripts which will be published in the Memoirs of the Department. By his death the Department suffers a most serious loss; Dr. von Krafft was not only specially trained for scientific work, but he was an exceptionally keen mountaineer and as such invaluable as an explorer of the highest portions of the Himalayas.

Dr. T. L. Walker resigned his appointment on the 28th December 1901, having been nominated Professor of Mineralogy at the University of Toronto.

Mr. G. A. Stonier was appointed officiating Chief Inspector of Mines and as such acted under my supervision, but on the Inspection of Mines office being established as a separate department under Government, Mr. Stonier was confirmed as Chief Inspector of Mines under date 7th January 1902, and the Geological Survey lost his services as specialist.

Mr. R. R. Simpson was appointed by His Majesty's Secretary of State for India a coal-specialist on the 13th November 1901, but his services were utilised as Inspector of Mines under Mr. Stonier.

It will thus be seen that owing to deaths, resignations and the necessities of the Inspection of Mines Office, the Department was deprived of the services of four officers during the greater part of the

year, to which must be added the absence on furlough during part of the year under review, of Messrs. Oldham, Middlemiss, Holland, Smith and Dr. Noetling, which casualties have greatly reduced the total output of work which might have been expected from the Department.

### I.—Museum and Laboratory.

During the past year the curatorship was held from June till November by Dr. T. L. Walker and for the remainder of the year by Mr. Hayden.

The arranging, cleaning and labelling of the cases has progressed steadily. It has also been found necessary to undertake the complete cleaning and re-labelling of the large and valuable "Klipstein" collection of foreign fossils: for this purpose a special grant has been sanctioned by the Government of India and a staff of native label-writers has been engaged. The work of cleaning the cases and specimens will probably be completed by June 1902, but more than a year will be required for the re-labelling.

Several valuable additions have been made to the collections during the past year, one of the most interesting of which is the Sindhri meteorite; this is a stony meteorite, weighing 7,837 grammes, which fell on 10th June 1901. It may be remarked in this connexion that the Government of India, Department of Revenue and Agriculture, Circular No. <sup>45 G.</sup><sub>22-13</sub>, dated 28th April 1885, enjoining the despatch to the Geological Section of the Indian Museum of all meteorites falling in British territory, has become practically a dead-letter, and the attention of local Governments and of district officials might with advantage be drawn to it.

The following donations have been received during the year :—

<i>Donor.</i>	
Seven meteoric irons . . . . .	} Prof. H. A. Ward, Chicago.
Seven stony meteorites . . . . .	
Specimens of muscovite from Inikurti, Nellore district . . . . .	E. H. Sargent, Esq., Nellore.
Copper and copper slag, obtained in the smelting of Chalcopyrite, from Komai, Darjiling district.	F. Thompson, Esq., Sam Sing, Jalpaiguri.

Over three hundred assays and determinations, detailed lists of which will be found in the quarterly notes, have been made in the Laboratory during the past year.

The curator reports that he is greatly indebted to Mr. T. R. Blyth, Assistant Curator, for the valuable assistance rendered by him in the Museum and Laboratory.

## 2.—Palæontological work.

During the year the collection of fossils belonging to the department was largely augmented by most valuable additions collected by (1) Messrs. La Touche and Datta in Burma, (2) Mr. Hayden in Spiti, and (3) Mr. Vredenburg in Baluchistan. The naming and cursory examination of the same will take the entire recess season of 1902, but it will take years to fully describe the most important part of these fossil collections, and this will only be possible through the co-operation of palæontologists at home, as the material is of far too vast a nature for one specialist to describe during a life-time.

### (a) Descriptive work in India.

Dr. F. Noetling returned from leave on the 29th of October and resumed the description of the Tertiary fauna of Sind, in particular that of the Nari stage. The determination and description of the *Pelecypoda* is almost finished, but it is not intended to publish it as a separate memoir until the *Gastropoda* are completed, which will enable him to form a more accurate opinion on the fauna generally.

The examination of the *Pelecypoda* points to the conclusion that the age of the Nari stage can hardly be older than the Priabona beds of upper Italy, though it is even possible that they are somewhat younger. The Nari stage may therefore represent the top of the eocene series. The examination of the *Pelecypoda* has further proved that there is hardly any faunistic similarity between the Nari and the younger Gaj stage. This is a very important fact inasmuch as it would prove a faunistic break between the eocene-Nari and the miocene-Gaj series.

The description of the lower trias fossils of the Himalayas engaged Dr. von Krafft during the entire recess season of 1901 up to the day of his death. It is as yet impossible to say how far his descriptions of new species are ready for publication. Amongst his papers were found more or less complete descriptions of species belonging to the following genera:—

DR. VON KRAFFT on  
the lower trias fossils.

1. *Meekoceras*, Hyatt.
2. *Ceratites*, de Haan.
3. *Xenodiscus*, Waag.
4. *Hedenstræmia*, Waag.
5. *Frechiceras*, nov. gen.
6. *Sibirites*, Mojs.
7. *Proptychites*, nov. gen.
8. *Flemingites*, Waag.
9. *Nannites*, Mojs.

These are also partly illustrated by drawings, but the work of revising the text and comparing the type specimens with the same, not less than selecting suitable figures to illustrate those which have not yet been figured, has still to be done. The work when completed will no doubt form a very valuable contribution to triassic palæontology, even should it turn out to consist of fragmentary notes only.

(b) *Descriptive work in Europe.*

The work mentioned on page 4 of last year's General Report is still in progress.

Professor R. Zeiller has entirely finished the description of the Gondwana flora, and the work is printed and will appear within the next few weeks.

IN FRANCE.

Dr. F. L. Kitchin has furnished the full description, with plates, of the *Trigoniæ* of the Kutch fauna, which will now be published as part 2 of

IN ENGLAND.

Volume III, Series IX, of the *Palæontologia Indica*.

There is only a small remnant, consisting of the remainder of the *Lamellibranchiata*, which is awaiting description by Dr. Kitchin, which will be done during next year.

The older palæozoic fossils of the Himalayas, the description of which should be contained in *Palæontologia Indica*, Series XV, Vol. I,

are still in England awaiting naming, but up to date it has not been possible to secure the services of an expert. Palæontologists are few in England, and apparently there are none with sufficient time at their disposal to undertake Indian work.

1. Professor V. Uhlig has sent a first small instalment of the description of the Spiti fauna consisting of the genera *Phylloceras*, *Lytoceras*, *Haploceras*, *Hecticoceras*, *Oppelia*, *Aspidoceras* and *Holcostephanus*, which will be illustrated by 18 plates. There are 74 plates lithographed up to date, so it may be expected that the description of the remaining genera will require several years for their completion.

2. Professor Dr. Diener is at present engaged in describing the permian and carboniferous fossils of the Himalayas, which had recently been collected by Mr. Hayden and Dr. von Krafft, and these will probably not be finished before the end of 1902-1903. He has also promised to undertake the description of the new additions to collections of upper trias fossils.

### 3.—Publications and Library.

The following publications were issued during the past twelve months:—

General Report on the work carried on by the Geological Survey of India, from the 1st April 1901 to the 31st March 1902.

*General Report.*

Volume XXX, Part 3. Sivamalai series of the Eleolite-Syenites, by T. H. Holland.

*Memoirs.*

Part 4. Report of the Geological Congress of Paris, by Dr. W. T. Blanford, F.R.S.

Volume XXXI, Part 1. Geology of the Son valley in the Rewah State, etc., by R. D. Oldham, P. N. Datta and E. Vredenburg.

Part 2. A Geological sketch of the Baluchistan Desert and part of eastern Persia, by E. Vredenburg.

Part 3. Petrological notes on some Peridotites, Serpentine, etc., by Lieut.-General C. A. McMahon, F.R.S.

Volume XXXII, Part 1. Recent Artesian experiments in India, by E. Vredenburg.

Part 2. Report on the Rampur Coalfield, by G. F. Reader.

- Volume XXXIII, Part 2. On some auriferous localities in India, by H. H. Hayden and Dr. F. H. Hatch.
- Volume XXXIV, Part 1. On a peculiar form of altered peridotite in Mysore State, by T. H. Holland.
- New series Vol. I, No. 3. Fauna of the Miocene Beds of Burma, *Palaontologia Indica.* by Dr. F. Noetling.
- Series X, Vol. IV. Title page, contents, etc.
- Series XV, Vol. III. Title page, contents, etc.
- Popular Guide to museum.* Meteorites, No. 3, Appendix.
- Annual Report of the Inspector of mines for the year ending *Inspector of mines.* 31st December 1900.
- The additions to the library during the year 1901-02 amount to 1,922 volumes of which 1,132 were acquired by presentation and 790 by purchase.
- Library.*

## PART II.—FIELD PARTIES.

During the year ending the 31st March the officers of the *Distribution of officers.* Department were posted as follows:—

### SUPERINTENDENTS.

- |                          |  |
|--------------------------|--|
| Mr. R. D. Oldham .       | Returned from furlough on the 17th July 1901; was posted to the survey of the Simla hills and the Sulaiman hills west of Dera Ghazi Khan. Left Calcutta on the 29th August 1901 and returned to headquarters on the 18th March 1902. |
| Mr. T. H. D. La Touche . | Returned to headquarters from the northern Shan States on the 29th April 1901; engaged in drawing up his report. Was again posted to the northern Shan States from the 3rd November to date.   |
| Mr. C. S. Middlemiss .   | Returned from furlough on the 18th December 1901 and was posted to the Vizagapatam hill tract from the 8th January to date.  |

## DEPUTY SUPERINTENDENTS.

- |                   |   |
|-------------------|---|
| Mr. P. N. Bose    | . . . During April was engaged in surveying parts of the Jhaintia hills of Assam; returned to headquarters on the 11th May 1901, where he was engaged in drawing up a report on the previous season's work. Was posted to the same area for the cold weather period and left Calcutta for the field on the 2nd December 1901. |
| Mr. T. H. Holland | . . . During April 1901 was engaged in examining the neighbourhood of Dhamsala hill station and afterwards was posted to the survey of the Kangra district. Returned to Calcutta on the 22nd September and left on furlough on the 29th October 1901.   |
| Mr. P. N. Datta   | . . . During April and part of May was engaged on the survey of the northern Shan Sates; returned to headquarters for recess work on the 13th May 1901 and during the cold weather months was again posted to the same area; left for it on the 5th November 1901.  |
| Mr. F. H. Smith   | . . . Returned from furlough 18th November 1901; was posted to the Chota Nagpore mineral survey and left for his post on the 5th December.  |

## ASSISTANT SUPERINTENDENTS.

- |                  |  |
|------------------|--|
| Mr. H. H. Hayden | . . . During the rainy season of 1901 was deputed to the Spiti Himalayas to complete his previous surveys of that area. Left on the 7th June 1901, returning from there on 29th October, when he took over the duties of curator of the Museum. On the 4th March he was deputed to Assam to report on the condition of the hill section of the Assam-Bengal railway and the coal-seams which occur in the neighbourhood. |
|------------------|--|

Mr. E. Vredenburg . . .	Had been posted to Baluchistan during 1900-1901 and remained there till the 1st October 1901 when he returned to headquarters for the purpose of describing his collections. He returned to the survey of Baluchistan in February 1902.
Dr. T. L. Walker . . .	Curator during the recess season of 1901 ; resigned his appointment in October 1901.
Dr. A. von Krafft . . .	At headquarters during the recess season of 1901 ; died on the 22nd September 1901.

PALÆONTOLOGIST.

Dr. F. Noetling . . .	On furlough during the recess season till 29th October 1901 ; accompanied the Director on a tour to Burma during November and December. In March 1901 was deputed to examine the Sambhar Lake in Rajputana.
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SPECIALIST.

Mr. G. A. Stonier . . .	During April 1901 was performing miscellaneous duties in connection with Mines inspection, and also was on deputation to Bikanir to select boring sites. Later engaged on the Jherria coal survey. Services transferred to the Department of Revenue and Agriculture as Chief Inspector of Mines in India, 7th January 1902.
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SUB-ASSISTANTS.

Hira Lal and Kishen Singh.	Were during 1901-1902 attached to parties of Messrs. Stonier, Datta and Smith.
----------------------------	--

ASSISTANT CURATOR.

Mr. T. R. Blyth. . . .	Was on duty at the Museum during the entire year under report.
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## A.—ECONOMIC ENQUIRIES.

## I.—Gold.

During the year under report only one party could be spared for systematic gold prospecting and that could only be done on a limited scale in Chota Nagpur.

CHOTA NAGPUR.  
*Mr. F. H. Smith.*  
*Sub-Assistant*  
*Hira Lal.*

Mr. Smith, assisted by Sub-Assistant Hira Lal, examined parts of the Anandpur, Porahat and Manharpur districts of Singbhum, lying to the north of Sonua and Goilkera, and to the north and south of Manharpur stations of the Bengal-Nagpur Railway.

I myself visited the party during March and was much pleased at the progress made in the prospecting operations, regarding which Mr. Smith has sent in a preliminary report from which the following notes may be quoted:—

*Director.*

*Geology.*

“The geology of the area is very simple on the whole. The rocks consist of the schists and slates of the transition system, with a very constant east and west strike, and dip varying from vertical to 50° N. At the same time there is a good deal of local crushing of the beds, with frequent evidence of faulting on a limited scale. In the hilly country the rocks are traversed by well-defined sets of cleavage and joint planes; but the pressure which caused them has often disappeared, especially near the hill-tops, and the rocks shew a tendency to fall open, giving rise to extensive vertical fissures, which penetrate far into the hill-side. These fissures are a source of considerable confusion. The old workings are frequently found passing into them, and as the fissures are generally filled loosely with fragments fallen in from the sides, it is difficult to tell where the fissure begins and the working ends. It is quite possible that the ancients followed these clefts originally, taking them for ‘older workings’ and hoping to find treasure in them.

The country rocks shew much weathering, and they are hydrated to a considerable depth. The most common type is a soft greenish clay-slate, locally steatitic or sandy. The harder rocks consist of chloritic, micaceous, hornblendic and haematitic schists, with their bands of compact felsite. They shew, under the microscope, signs of great crushing and metamorphism, having a general epidioritic

appearance, with a few strings and trails of mylonitic quartz fragments and minute crystals of chlorite or mica, and some secondary calcite. Occasional beds of compact dolomite occur, and also bands of segregated haematite and quartz-haematite breccia, in the slates.

Trap dykes are of somewhat rare occurrence. Quartzite beds are also very exceptional. A broad band of quartz-haematite schist occurs in the Ankwabanga hill, and is slightly auriferous; but the only distinct bed of quartzite met with is that mentioned by Dr. Hatch at Parhardiah. This is twenty or thirty feet in thickness and traverses the country for a long distance, being seen again in the Koel river at Bera, eight miles to the north-east. There are probably one or two smaller beds associated with this main band at Parhardiah, and the rock is auriferous, though the gold appears to be very thinly disseminated through it.

Some of the leaders mentioned below, and possibly one or two of the reefs, may also be due to the metamorphism of original quartzite beds in the slates, but the great majority are probably true reefs—fissures gradually filled up with secondary quartz deposited with other minerals by percolating water.

Quartz reefs occur abundantly throughout the transition rocks, and the hilly jungle tracts are covered with quartz pebbles and boulders derived from their outcrops.

The reefs may be conveniently divided into three classes by their visible characteristics.

*Class 1.*—Conspicuous reefs of compact, pure white, ‘hungry-looking’ quartz, which stand out boldly from the surface, and have a considerable influence in the shaping of the country, often occurring along the crests of hills. These seldom contain more than minute traces of gold, and may be neglected by the gold-seeker.

*Class 2.*—Reefs of a foot or more in thickness, of ferruginous quartz, generally blue or grey in colour. The latter characteristic is probably quite accidental, but the presence of iron scattered through the quartz constitutes the chief difference from class 1.

The presence of iron is a sure sign of the likelihood of gold, and most of these reefs are auriferous.

The iron also affects the physical character of the reef. The films and threads of iron ore are quick to hydrate, and the soft mineral resulting is washed out of the crevices, leaving the reef honeycombed and quite unable to withstand weathering in the way

the compact 'hungry,' quartz-reef does. As a matter of fact the reefs of class 2 seldom reach the surface intact, being disintegrated below; and in many cases this goes on to such an extent that for some feet below the surface, even of the country rock, the reef may be traced down as a band of rubble consisting of fragments of quartz set in red mud, washed in from above and augmented by the hydrated iron. When this occurs at the bottom of an old working, it is impossible to tell exactly where man's work left off and nature's began.

*Class 3—'Leaders.'* This is a convenient term to denote thin strings and veins of quartz generally from half to three or four inches in thickness. The transition rocks of this area are seamed by such leaders everywhere and in all directions. The great majority of them resemble the reefs of class 2, being of blue, ferruginous quartz usually auriferous and often fairly rich in gold.

Reefs are found cutting the rocks in all directions, but as they were originally deposited in fissures along a line of weakness, it is natural to find that they shew a decided preference to follow a joint plane, and still more often the plane of bedding . . . . ."

Mr. Smith's report contains also some interesting notes on the traces of gold contained in the alluvial deposits and in the débris at the foot of hills, which are frequently worked by the native race of gold-washers, but it is quite evident that these gold sources have no practical importance for the scientific miner, beyond guiding him in some instances in his prospecting operations.

More important are the so-called old workings, which abound in

*Old workings.* Chota Nagpore and which are well known to the natives,—Kols or Mundas—who do not seem to possess any very well defined traditions about the origin of these old "mines." Mr. Smith has carefully examined a large number of these old workings situated in the districts named above. To do so they had to be completely "un-bottomed" in every single instance, as no indications are shown at the surface of the purpose for which the workings had been undertaken. I have myself seen the ancient workings in Rhodesia, South Africa, and can state with certainty that the latter differ in most instances much from these Chota Nagpore workings, although geologically there is a close resemblance in the geology and even the character of the reefs found in both areas. The Chota Nagpore workings differ also, as far as examined, from the numerous old workings in Mysore, which latter seem to show the possession by the ancient miners of greater skill and mining system.

Every indication seems to point out that the Chota Nagpore workings, as far as examined, are nothing more than old prospecting shafts and trenches, and in most cases appear to have been planned by unskilled men, and must have been abandoned by them without having led to the discovery of paying reefs, in the same manner as was done by so-called experts during the late gold "boom" in 1889 and 1890. Whether any of the many hundreds of these old workings will actually be found to be the remains of ancient gold mines, only a long continued and careful search will reveal.

All that can now be said after Mr. Smith's carefully conducted inquiry is that practically all the quartz reefs, together with the network of leaders which traverse the country, contain a certain amount of gold, the richest amongst them from three to four dwt., but then only in patches. It may be said that the average yield is not more than a dwt. per ton, which under the circumstances could never pay for regular mining operations.

Only one of the smaller reefs, hardly to be called such, but rather a small irregular leader, gave encouraging results on assay, and in that locality an irregular vein of argentiferous galena contains also an appreciable amount of gold, but the vein nips out and has not been further traced. To test this more extensively, a closer study, *i.e.*, some development has to be done before a definite opinion can be pronounced. The assay of the galena alone, which consists of an irregular string of nests in the quartz, has yielded:—

79·3 per cent. of lead.

34 oz. 2 dwt. 17 grains of silver to the ton of lead, and

11 oz. 2 dwt. 3 grains of gold to the ton of lead.

This result seems to be exceedingly encouraging, but as only a small outcrop has been observed, it will require actual development to prove more than the existence of a patchy vein of galena.

## 2.—Copper.

Copper ores were known to exist near the south eastern boundary of the Darjiling district, and as they had attracted some attention, it was considered expedient to despatch an officer to the spot for the purpose of obtaining a report on the same. Mr. Hayden was therefore deputed to examine this copper ore. The exact locality is situated

DARJILING DISTRICT.

Mr. Hayden.

about four miles north of Sam Sing Tea Estate in the Jalpaiguri district, and it had not been reported on previously.

The country rock consists of soft grey and green slate belonging to the Daling series, and is greatly crushed and contorted with a general strike of north-east to south-west and usually a high dip to north-west. Small bodies of copper ore occur at various places in the slates and in quartzite bands associated with them and usually amount to little more than strings of aggregations of copper pyrites extending for only a few inches in any direction, excepting at one place near the left side of the Mo Chu (Murti river), where the ore is in form of fairly large masses of chalcopyrite with some quartz in bands parallel to the bedding planes of the rock.

The assay value of the ores varies a good deal and no reliable opinion could be given of the value of the locality, as it is scarcely at all developed, but it seems to be encouraging enough to have it developed with the view of ascertaining whether it could not be worked to advantage. A considerable sum of money will be required to develop it extensively enough to ascertain the extent and richness of the ore body, which seems irregular in character.

### 3.—Coal.

Government having sanctioned my proposal to prove the coal-seams of Palana in the Bikanir State by borings,  
BIKANIR.
a contract was entered into with a private firm to undertake one diamond drill to a depth of 1,000 feet in order to ascertain whether there are other coal horizons besides the one already known. Mr. Stonier, the specialist of the department, was deputed to Palana to select the site which in all probability would offer the best chances for such a boring, and a tank capable of holding 10,000 gallons of water was also prepared, but it is very regrettable that after a delay extending to about eight months the contractors have failed to carry out the undertaking, the failure being due to their selection of unsuitable machinery for this special locality. As no other private contractors are available in India, the task of proving the coal bearing formation of Bikanir has had to be postponed until Government possesses its own boring plant.

Mr. Stonier was deputed in December 1900 to join Mr. Weightman (the Engineer of the Jherria Connection-Survey) at Katras. The objects of the Railway Survey were two-fold—  
JHERRIA.

(1) To determine the best route for a connection between the alignments already selected for the Gya Katrasgarh (East Indian Railway) and the Midnapur-Boojoodih (Bengal-Nagpur Railway) Railways, to serve as a main line of communication between Mogulserai and Khargpur.

(2) In connection with 1, to consider how branches and sidings can best be laid off this main line, so as to enable the Jherria coal-field to be opened up in such a way that both the East Indian and the Bengal-Nagpur Railways may have equal or reciprocal facilities for dealing with the traffic and may share equally in its expansion, at the same time keeping in view the future development of the coal-field, and the desirability of affording to all colliery proprietors the option of sending their coal by whichever route they may prefer.

After the survey had been in progress for a couple of months and a rough scheme had been decided upon, it became evident that a mining and geological expert's advice was necessary before the alignment of the colliery line could be fixed. It was expected that a month spent on the field would amply suffice for the collection of geological and mining information required for the purposes of the railway survey. It soon became evident, however, (1) that mining operations were confined to a small area, (2) that very little was known about the remainder of the field. At first the chief object was the mapping of the upper seams, but as the work progressed it became necessary to examine the lower seams, and finally the survey of a small area was extended until it embraced the whole field. Jherria was geologically surveyed by Mr. T. H. Hughes in 1865 (*vide* Mem. Geol. Surv. Ind., Vol. V, Part 3), and in 1891 Mr. T. H. Ward (Assistant Manager, E. I. Ry. Collieries) numbered and traced out the seams (Rec. Geol. Surv. Ind., Vol. XXV, Part 2, 1891).

The coal measures occur as an outlier of Gondwana beds surrounded by metamorphic rocks, the boundary in most cases (according to Messrs Ward and Stonier) being a well marked fault. The area is roughly lozenge-shaped with pointed ends, and has a major axis, W. N. W. 27 miles long and minor axis  $9\frac{1}{2}$  miles long.

The rocks in descending order are :—

- (1) Raniganj system.
- (2) Ironstone shales.
- (3) Barakar system—
  - (a) Damuda series.
  - (b) Talchir series.

(1) The Raniganj beds occupy an area in the south-western portion of the field, and have recently been proved to contain two workable seams of coal, near the base of the system. The seams are not worked on account of the want of the railway communication. It is specially interesting to note this new development in Jherria. Notwithstanding the fact that in the adjoining (Raniganj) coalfield, the Raniganj measures contain the chief seams, an impression had been formed that in Jherria these upper measures did not contain workable coal and the system had been neglected by speculators who confined their attention to the seams in the vicinity of the railway, which was constructed shortly after Mr. Ward's survey.

(2) The Ironstone shales are conformable to the overlying and underlying systems, but the upper and lower boundaries are not well defined as in the case of the Raniganj field. An east and west fault limits the outcrop in the western area, but it spreads out easterly and occupies a fan-shaped area in the south-western portion of the field. The system does not contain, but it overlies thick coal seams.

(3) The Barakar system is divisible into two series of which the Talchirs are unimportant from a mining standpoint. The upper series has at least 18 seams (No. 18 was discovered during the progress of Mr. Stonier's survey) which vary from 5 to 30 feet in thickness and have been numbered in ascending order. At both ends of the field the dip is high, but over a large area the seams are well situated for easy and cheap working, though in a number of places they are dislocated by strike faults and penetrated by dykes. The strike faults are numerous and their baneful influence on the value of properties is only beginning to be realized. The dykes are of two kinds, (a) mica-peridotite, (b) dolerite. The latter are generally unimportant, but the former have been particularly destructive, for they not only cut through the seams, but in many places pass in loccolitic form along the coal rendering it absolutely valueless for the present market. A number of the workable seams are being actively mined, but operations are chiefly confined at present to the winning of coal near the outcrop in the area which lies to the east and south-east of the Khoda river (see Ward's map). The workings are chiefly on seams Nos. 10 to 17 and occupy a narrow strip in the form of an arc of a circle, chiefly to the south of the existing East Indian Railway branch line. The deepest shaft is 320 feet in depth.

The seams below 10 are worked in some parts of the field, but they are not as important as the seams above 10.

At the extreme south-eastern area seams Nos. 13 and 17 are being mined. The former dips at an angle of  $28^{\circ}$  and the latter at  $48^{\circ}$ .

In the area west of the Khoda river there is little known about the seams: several of the mouzahs are being prospected by tunnels and deep bores. The general opinion held has been that this end of the field is of little value, but the opinion is based on a small amount of information and at present is not justified. The quality of coal very recently found compares favourably with the average of Jherria coal.

The main line and two colliery lines were pegged out by the Railway Survey party, one running near the outcrop of No. 17 and the other above the outcrop of No. 16 seam. At the conclusion of the field work the East Indian Railway suggested a main line running through the coal-field. A report was written by Mr. Stonier and forms Appendix C. to Mr. Weightman's report, which was furnished to the Government of India. The whole question was considered by a Conference at Simla in July 1901 at which Mr. Stonier was present and gave geological evidence. The report of the Committee which sat at the conclusion of the Conference has been published by the Government of India who adopted most of Mr. Weightman's suggestions.

The extension of the Burma State Railway from Mandalay to Lashio rendered it desirable to develop the coal-fields of Lashio, concerning which Dr. F. Noetting had furnished a report some years ago. Mr. La Touche being already engaged on survey work in the northern Shan States, he was deputed to undertake the preliminary inquiries and he is now engaged on that work. Concerning the coal seams he reports as follows:—

UPPER BURMA, LASHIO.  
*Mr. La Touche.*

"The Lashio coal-field is situated in the valley of the Namyao river about five miles to the north of Lashio in Lat.  $23^{\circ} 0'$ , Long.  $97^{\circ} 50'$ . The tertiary beds, in which the coal occurs, extend over an area of at least ten miles in length from east to west and two to three miles in breadth. They consist of soft sandstones and sandy clays, without any bands of hard rock, in fact, the hardest rock in the whole series, as seen in the outcrops, is the coal itself. The coal is confined to the lowest beds of the series, and the only outcrops found are situated along the western and southern edge of the basin. To the north and east the coal-bearing beds are overlaid by higher beds of the series, and do not appear anywhere at the surface. It is

impossible to say, without boring, how far the coal extends in that direction, and I have therefore marked sites for borings and arranged with the Engineer-in-Chief of the Mandalay-Kunlon Railway to have them put down as soon as the necessary tools can be procured. The coal as seen in the outcrops, all of which I have had excavated in order that the thickness might be measured, is very variable in thickness, and it is not at all certain that it forms a continuous seam. The thickness varies from 30 feet in the most westerly outcrop, to four feet six inches. No estimate of the total amount of coal available is therefore possible until the continuity of the seams and their extension northwards is proved by borings. Samples of the coal have been taken and will be submitted to analysis. The coal is always found below the natural water level of the country, and is therefore saturated with moisture, and although it can be obtained in large masses it has a tendency to split into small fragments on drying. The roof and floor of the coal is invariably bad, consisting of soft sand or sandy clay, and unless a considerable portion of the coal itself is left as a roof to the workings, much timbering will be necessary. A very considerable water discharge will also have to be contended with."

Mr. Hayden was deputed to Assam to examine the coal seams which occur in the Nambor forest on the eastern flank of the Mikir hills, situated near the Assam-Bengal Railway line. The coal occurs chiefly

ASSAM.  
Mr. Hayden.

in two localities, about eight miles west of Borpathar, and in each case the outcrop is seen only in the river bed. The seams lie almost horizontally, striking north-north-east—south-south-west; the coal appears to be dirty and of very inferior quality. The samples are being assayed in the laboratory of the department.

Coal is occasionally developed in the marginal sandstones of the cretaceous system in the Jaintia hills well within the Shillong plateau. Mr. Bose found two noteworthy occurrences of such coal, one at Wapung

ASSAM. SHILLONG  
PLATEAU.  
Mr. P. N. Bose.

(seven miles east of Jowai), and the other at Lenkensmit (Dongchala on map), six miles south of Wapung. It is an excellent caking coal. The seams nowhere exceed five feet or so, and they are, like the nummulitic coal of the area, very variable in thickness. From the exposures observed at both the places, there is a probability of a workable extent of the coal. It will probably, however, have to remain untouched for a long time, as the cost of its transport to the plains of Sylhet and Cachar would be quite prohibitive.

In the area under description workable coal of nummulitic age occurs at Umlotodo (Lakadong) and at Narpo. The Lakadong coal (which occurs in a band of sandstones intervening between two bands of nummulitic limestone) has long been well known and was reported upon by Dr. T. Oldham in one of the earliest memoirs of the Survey ("Memoirs," Vol. I). It was worked to some extent about 40 years ago, chiefly by adits driven from the steep faces of deep glens where the coal is exposed, and to a small extent by shallow pits. The old workings have been closed since the earthquake of 1897.

*Nummulitic coal in the*  
JAINTIA HILLS.

#### 4.—Miscellaneous Minerals.

During his geological surveys in the Jaintia hills Mr. Bose discovered two unpromising oil springs. The locality is about eight miles east of Mulagul (Lat.  $25^{\circ} 3'$ , Long.  $92^{\circ} 29'$ ) close to the eastern feeder of the Dona river. The oil oozes out slowly from greenish grey fine-grained upper tertiary sandstone, similar to the springs in the Khasimara valley, which were reported on last year.

*Petroleum.*  
Mr. Bose.

One of the first tasks which Mr. Holland undertook during the progress of the Kangra survey consisted in an examination of the slate quarries of Kanyára on which he has furnished a report, now about to appear in Memoirs, Vol. XXXIV, Part 3.

*Slate.*  
Mr. Holland.

The Sambhar lake in Rajputana, one of the most important sources of the Indian salt supply, has been observed to furnish diminished quantities of this mineral during the last year, and Dr. Noetling was therefore deputed to specially report on the locality. That officer's selection was in part due to the fact that he has already obtained experience in matters connected with salt, owing to his having made a close study of the bitter lakes of Palestine, on which he has published a report.

*Salt.*  
Dr. Noetling.

After a careful examination of the geological features, Dr. Noetling found that the lake is an entirely closed basin surrounded on all sides by the Aravali series. This basin of unknown depth is filled up by horizontally bedded, alluvial strata consisting mostly of fine micaceous silt, containing a few beds of hard calcareous strata, locally called

kankar. In several instances it was observed that the alluvial strata rest directly on the Aravali series, and Dr. Noetling concludes therefore that no other beds of either mesozoic or tertiary age exist inside this basin, but that the bottom of the lake is formed by the Aravali series unconformably overlaid by the alluvial silt.

The silt is percolated by a strong brine which rises up to a certain, for the present unknown, level in the centre of the lake and from there radiates towards the shore. The observed fact that in all the wells along the periphery of the lake the brine radiates from the centre is a distinct proof that it must rise from wells in the lake itself, and Dr. Noetling opines that it probably rises under considerable hydrostatic pressure along a fault in the Aravali series which is superficially hidden by the silt. This brine must be considered as the original source of the salt.

When there is a good rainfall, the shallow depression on the surface of the alluvial silt is filled up by a sheet of sweet water of shallow depth; this water takes up the easily soluble sodium chloride from the underlying silt, which it leaches, so to speak, of its saline contents. When the water resting on the silt is agitated by the wind, the more concentrated parts at the bottom are replaced by water less saturated with salt and thus gradually a very pure brine, which chiefly contains sodium chloride, is formed on the top of the silt. By evaporation this brine is more and more concentrated and eventually used for the manufacture of Kyar salt. As the manufacture of Kyar salt is solely dependent on the secondary brine, it is obvious that in years of scanty rainfall, when the lake is not sufficiently filled, the production must fall off, as there is not enough water for the production of the secondary brine. It is further obvious that when there is again a succession of good monsoons, when the lake will be filled to the required depth, the production of salt will rise to its former height.

So far no apprehension should be felt as to probable exhaustion of the lake unless it could be proved that the supply of the primary brine rising within the lake is failing. There are absolutely no observations with regard to this; it is not known whether, for instance, the level of the primary brine has been influenced by the years of scanty rainfall. Dr. Noetling thinks it has not, or at least not materially, because the pits (khals) from which the primary brine is baled out for the manufacture of pan salt are all situated almost along the shores of the lake. If the level of the brine had fallen to some extent, the edge of the brine would have receded towards the

centre, and instead of remaining as they are close to the shore, the pits would have had to be dug further away from it, towards the interior of the lake.

In years of insufficient rainfall, when there is not enough water to fill the Kyars, the production of salt would, therefore, chiefly be dependent on its extraction from the primary brine, and unless it could be proved that the supply of this primary brine is failing, there is no reason to assume that the Sambhar lake has to be abandoned as a source of salt.

### 5.—Landslips.

Early in March Mr. Hayden was deputed to Cachar to report on the geological features of the Hill Section of the Assam-Bengal Railway. He found the local rocks to consist of blue and carbonaceous shales of upper tertiary age, containing some *gypsum* and other soluble sulphates with considerable quantities of *kaolinite*. His analyses of the shale and its component minerals are not yet completed, but he reports that the results so far obtained point to the fact that the movements which have taken place in the cuttings and tunnels are due in part to the presence of the above minerals. The cuttings, however, frequently pass through old landslip material, the removal of a part of which has resulted in a renewal of movement throughout the mass, and until equilibrium has been restored, this movement must continue. He recommends that certain precautions be taken to prevent, as far as possible, serious slips, chief among these being extensive and appropriate drainage. When the analyses of the specimens collected have been completed, a full report will be submitted.

ASSAM-BENGAL RAIL-  
WAY.

Mr. Hayden.

## B.—GEOLOGICAL SURVEYS.

### 1.—Madras Presidency.

Mr. Middlemiss returned late in December from furlough and was posted to the Vizagapatam hill tract; he has sent in a short summary and reports as follows:—

“I arrived in camp on the 9th January, so that the present account is the result of only about 2½ months’ work, of

VIZAGAPATAM HILL  
TRACTS.

Mr. Middlemiss.

which the earlier weeks were spent in familiarising myself with the rock groups treated of by my predecessors Dr. Walker and Mr. Smith. The work done is a continuation of theirs in every respect, and introduces little of any novelty.

I entered these so-called Agency Tracts *via* the Minamalur ghât in the Madgole zemindari, and have endeavoured to traverse and partially map in detail the country above the ghâts lying between a line drawn north-west across the hills from the Minamalur ghât and the parts surveyed by Walker. This was chiefly in the Jeypore State, and includes the north eastern part of Atlas sheet 93 (S.E.) and the parts above the ghâts in Atlas sheet 108. The whole area is a portion of the 3,000-foot plateau which here and there bears peaks rising to 4,000 and even 5,000 feet. It is generally forest-covered and sparsely dotted with villages along the flat rice-growing alluvial valleys.

The great series of transition metamorphic rocks, concisely described under the heading of 'Crystalline Schists' by Smith (General Report, G. S. I., 1899-1900, pages 154-157), and as the 'Khondalite Schists' by Walker (Memoir on the Geology of the Kalahandi State, Central Provinces, Mem. Vol. XXXIII, Pt. 3, in the press), are continued southwards, as was to be expected, into the area mapped by me this year. But in this area they present the fuller facies as described by Smith, including considerable beds of ferruginous schists, containing much haematite and limonite and bands of garnet magnetite rock, besides crystalline limestone, etc., and the typical quartz-garnet-sillimanite rock which is everywhere extremely well developed. Although Walker has not mentioned these highly ferruginous varieties of the transition schists, it seems probable that they are not entirely absent in the area mapped by him, as I have traced them up to and even into that area. They are well seen round about Dasmampur for instance [Atlas sheet 108 (N.)] and are locally used for making iron.

The conjunction of iron-bearing beds with crystalline marble (sometimes, as mentioned by Smith and Walker, containing scapolite and diopside) and with quartz-garnet-sillimanite rock (typical Khondalite of Walker) reminds me of the somewhat similar association of rock types at Madukarai near Coimbatore, at Uttukuli and Viziamangalam, at Satyamangalam, and at other scattered localities in the Coimbatore district.

The great Gneissic series which underlies the transitions includes, as far as I have seen, most if not all the rocks variously grouped as 'garnetiferous biotite-granite and granulite,' and 'hypersthene-granulite' by Smith in Ganjam, and as 'granitoid gneiss' and 'charnockite' by Walker in the neighbouring area of Kalahandi State. It is too early yet to state any positive conclusions, but it seems extremely likely that the charnockite series, though keeping a marked individuality over great areas, does elsewhere show strange varieties and modifications with apparent passages into more acid biotite-bearing gneisses, as both Smith and Walker have testified (General Report, G. S. I., 1899-1900, pages 158 and 170), and as I have elsewhere described in the Salem district.

Lateritic plateaux at about 4,000 feet are commonly met with from Nelam hill near Wondragedda up to the hills round Giriliguma. In all cases which I have examined my observations confirm those of Smith in Ganjam that they are confined to areas of the transition schists, the laterite being directly derived from them by decomposition and concentration of the iron. This seems such a natural and normal result, when the highly ferruginous nature of part of the transitions is taken into consideration, that, in contemplating these striking horizontal plateaux running far round the horizon as they frequently do, the puzzle is not to account for the laterite, but to account for that which it has preserved under its iron-bound cap, namely, the truncation of those hills to about the 4,000-feet level. For, as far as my observations go here, the lateritic plateaux are not horizontal deposits fringing and burying what were once pointed peaks or irregular hills, but a genuine layer disposed above previously truncated hills."

## 2.—Burma.

The geological surveys undertaken during the season 1900-1901 and reported on in last year's General Report left so many points in Burman geology unexplained, and others on which the several observers differed considerably in their respective views, that it appeared necessary to revise some portions of this survey. A systematic geological survey, as conducted in other parts of the Indian Empire, is quite impossible in Burma owing

NORTHERN SHAN  
STATES.

Mr. T. D. LaTouche.

Mr. P. N. Datta.

The Director.

Dr. F. Neetling.

to the immense development of dense undergrowth in the vast forests which cover the greater portion of the country, and to this difficulty must be added the great thickness of superficial deposits, mostly of a lateritic nature, which cover all formations alike, and obscures in most places the geological structure entirely.

Accompanied by Dr. Noetling I visited certain parts of the northern Shan States during last cold weather to inspect sections regarding which there were some doubts as to the age of their component beds. The chief sections were those of Kyauk-Kyan, Bawgyo (Kyinsi), Napeng and Gokteik. After this inspection, Mr. LaTouche had to take up the examination of the Lashio coal-field, but before doing

so, he devoted some time to further researches near Wetwin and Padaukpin with the result of

obtaining from these localities a fine collection of middle devonian fossils.

Mr. LaTouche also succeeded in clearing up some doubts with regard to the presence or otherwise of a boundary fault at Kyauk-

Kyan, between beds which had last year been looked upon as mesozoic, and the devonian limestone.

These supposed mesozoic shales are undoubtedly devonian as their fossil contents (amongst which is a *Conocardium*) clearly show. The fault, however, does exist, having been proved by Mr. LaTouche by excavating the contact zone. It appears, probably, that the shales are intercalated between the limestone beds, which as may be seen at the Gokteik gorge form a wavy plateau, much shattered by local faults, and in a lesser degree, by extensive jointing.

The joint visits of myself, with the Palæontologist, Messrs. LaTouche and Datta have satisfactorily established that the Napeng beds, which had been looked upon by Mr. Datta as mesozoic, together with the Kyinsi beds are approximately both of the same horizon, containing absolutely an identical fauna, amongst which a *Conocardium* is always met with, and they are also identical with the Kyauk-Kyan beds, the whole, therefore, forming part of a vast complex of devonian beds which seem to form the greater portion of the Shan plateau in those parts. Whether the so-called Gokteik beds belong to the same horizon may with considerable certainty be inferred, but the fossils are too poorly preserved and moreover are, so far as has been established, not very characteristic. It is pretty certain, however, that so far nothing has been seen of beds which fill in the gap between the devonian and the mesozoic systems. The trias which was inferred last

year (see General Report, 1900-1901, page 19) from some fossils which had been wrongly determined, does not exist. These supposed beds contain devonian fossils and that has been established now beyond a doubt. Certain red shales (with limestones and sandstones) formerly doubtfully supposed to be jurassic, which are considerably developed west of Thebaw (near Namhsim and neighbourhood) have now been demonstrated to be mesozoic, probably either upper jurassic or lower cretaceous. Mr. LaTouche has found numerous well-preserved *brachiopods* in limestone beds of this formation near SeEng in the Namyao valley, and recently Mr. Datta has discovered *Trigonæ* in what appear to be the same beds near Hson-oi.

Roughly speaking, therefore, the centre of the Shan plateau consists of palæozoic strata; the bent and much shattered western margin of this plateau being chiefly made up of silurian strata followed eastwards by a devonian sequence, abundantly proved by fossils, and this complex of beds is overlaid in some manner not quite clearly established, by mesozoic (jurassic or lower cretaceous) beds near Bawgyo, west of Thebaw. Whether the lower mesozoic beds with the trias are developed in that region has not been demonstrated yet, but it seems doubtful whether such do exist.

### 3.—Assam.

A considerable amount of surveys were added to those completed by Mr. Bose during the last year; the following notes were taken from his preliminary report.

JAINTIA HILLS.  
Mr. P. N. Bose.

The area surveyed during last season is chiefly comprised between the Mangat and the Lubah rivers. The physical aspect of the eastern portion of the country presents a striking contrast to that of the western. Between the Mangat and the Mantedu (called Harry below Barghat) the undulating, gently-sloping Shillong-Jowai plateau drops suddenly from an elevation of about 1,400 feet to the Sylhet plains, the line of steep declivity corresponding roughly with that of the sharp faulted flexure which the rocks constituting the plateau have suffered at its edge. But east of the Mantedu-Harry river, the plateau to a great extent loses its distinctive character running into bold, scraggy spurs which merge on the border of the Sylhet and Cachar plains into a wild, jungle-clad tract of low hills.

The spurs and hillocks just mentioned are formed of upper *ter-*  
*Upper tertiaries.*                      tertiaries which attain enormous development in the  
 area north-east of Jaintiapur. Their thickness in  
 the Lubah valley cannot be less than 9,000 feet. They apparently  
 rest upon the nummulitic limestone presently to be described, with  
 perfect conformability, and are lithologically divisible into two sub-  
 divisions of which the lower consists of rather fine-grained, compact  
 greyish and greenish-grey sandstones with interstratified shales. The  
 upper division (well seen in the vicinity of Jaintiapur, Nichinpur, and  
 Mulagul along the northern boundary of the Sylhet district) indicates  
 shallow-water conditions, and is composed of false-bedded soft, greyish-  
 white, rather massive and indistinctly bedded grits and coarse sand-  
 stones with subordinate darkish clays which often affect a nodular  
 structure. In the sandstones by the Harry river below Nichinpur  
 curious pockets (due probably to contemporaneous erosion) were  
 noticed which are filled up with the clay just mentioned and with fine-  
 grained compact sandstone.

Both these divisions are highly disturbed, but the disturbance is  
 best seen in the lower of which good sections are exposed by the  
 Nowagong, the Harry, and the Lubah rivers. The dip is seldom less  
 than  $35^{\circ}$  and occasionally borders upon the vertical, and the strata are  
 sometimes found to be folded. The dominant strike is E.N.E.-W.S.W.  
 and the prevailing dip S.S.E.

The nummulitic limestone is absent at Sokha and Lamin near the  
*Lower tertiaries, num-*                      Mangat, but is fairly well developed at Nongta-  
*mulitics.*                                      lang (three miles east of Sokha). From the  
 plateau it was traced eastwards through Umlotodo  
 (Lakadong) to Narpo; and northward, in attenuated and interrupted  
 development to near Pombadong (five miles north of Nongtalang) and  
 to Umlawang (12 miles north of Narpo). As usual, its presence,  
 where it occurs in any force, is marked by "Swallow holes" of various  
 descriptions from small circular holes to enormous deep, thickly  
 wooded chasms and glens which are mostly drained underground.  
 At the foot of the plateau it is absent from Dowki on the Mangat,  
 to Laikro (three miles north-east of Jaintiapur) having in all proba-  
 bility been denuded away. It, however, appears in great strength in  
 the Harry valley at Barghat and Kharkhana, and continues eastward to  
 the Lubah valley, where it swells and widens out considerably, and is  
 superbly exposed, the weathered surface being generally thickly stud-  
 ded with fossils.

There are two distinct bands of limestone at Umlotodo aggregating some 250 feet in thickness, interposed between which occur some coarsish sandstones with carbonaceous layers.

Sandstones referable to this system (internally greyish white and externally brownish and ferruginous) with shale  
*Cretaceous rocks.* intercalations in which carbonaceous layers are occasionally met with, have a very wide expansion east of the Mangat forming an extensive upland with rounded billowy undulations. They have usually a very coarse conglomerate at the base in which pebbles, mostly sub-angular and seldom well-rounded, are thickly and confusedly embedded.

This sandstone formation contains fossils consisting of echinoids and bivalves in some profusion and a sprinkling of gastropods and cephalopods were collected from them at Sokha and Lamin. Among the bivalves a species of *Ostræa* (*Alectryonia*) is the most prominent, having been met with in some abundance throughout the area. The lower series consists mainly of massive, coarse-grained, thick-bedded sandstones which are usually conglomeratic towards the base, the pebbles in the conglomerate being generally well-rounded and arranged in parallel layers. Fossils are very scarce, and, when found, occur towards the top just below the upper series. Thin films of coal are occasionally found in them; and at one place (in the ravines south of Lamin) nests and strings of fossilised resin were encountered.

The cretaceous strata rest with well-marked unconformity upon a much eroded surface of the older rocks.

The Shillong series, which in the vicinity of Shillong consists chiefly of quartzites and quartzitic sandstones,  
*Shillong series and gneissic rocks.* passes into micaceous schists with occasional bands of well foliated gneiss when traced south-eastward to the Mangat valley; and this enhanced metamorphism is accompanied by increased disturbance.

Intrusions of coarsely crystalline massive granite with conspicuous well developed felspar were noticed in the  
*Intrusive rocks.*  
*Granite.* Shillong series at several localities, as in the Mangat between Pomsao and Simunting, near Doarblai, etc. There is also a magnificent display of it in the Mangat valley at and above Darrang, as well as in the valley of the Rangapani between Nongtalang and Sawasdia. Further eastward, however, it is entirely missed. In the gorge of the Mantedu above

Barghat there occurs granite, but it is highly quartzose, fine-grained, and occasionally gneissose.

Dioritic intrusions occur in some strength in the Shillong series in the vicinity of Smit at the northern boundary of the Lailangkot-Nongkram patch of granite, and also near Doarblai.

#### 4.—Punjab.

In the hills west of Dera Ghazi Khan the succession of rocks was found to be that described by Dr. Blandford, no additions of any importance having been made.

DERA GHAZI KHAN HILLS.  
*Mr. R. D. Oldham.* As a result of more extended surveys it has, however, been possible to determine the horizon of the quartzites and limestone classed by him as cretaceous. The massive white quartzites when traced northwards are found to be the same as those forming the southern end of the scarp of quartzites in which the petroleum of the Sherani hills occurs. In the Sherani country Mr. La Touche found the belemnite shales underlying these quartzites and in the country surveyed by Mr. Oldham they are everywhere separated from the lower nummulitic shales by a band of pseudo conglomeratic limestone, which he regards as a crush conglomerate precisely similar to that which is found at the top of the Dunghan stage in the Mari hills of Baluchistan. These two horizons show that the quartzites of the hills west of Dera Ghazi Khan must be regarded as the equivalent of the Dunghan stage in Baluchistan, that is to say as bridging over the interval between upper cretaceous and lower eocene.

When passing through Dera Ghazi Khan Mr. Oldham took the opportunity of examining the records of the erosion of the Indus river at that place and is preparing a memoir on the subject which will be of considerable interest from a geological point of view, though no longer of any direct practical applicability to the protection of the city from the Indus. He finds in the annual river surveys and records of erosion that the river has behaved as it should have been expected to from certain little known principles first established in 1858 by the French engineer Dausse, which does not appear to have been known to the engineers in charge of the protective works. If the embankments built to prevent the escape of flood waters over the river banks are

*Indus river near Dera  
Ghazi Khan.*

maintained through the next flood season, it is probable that the river will leave Dera Ghazi Khan itself, but that the danger of its breaking away through the low ground to the west and devastating the district will be increased.

### 5.—Himalayan Ranges.

During the hot weather recess season, May to October 1901, Mr. T. H. Holland was deputed to the outer Himalayan ranges of the Kangra valley and Lahoul to fill in gaps in our geological maps of those parts. *Parts of the KANGRA VALLEY and LAHOUL.*  
*Mr. T. H. Holland.*

At the conclusion of the season Mr. Holland proceeded on a year's furlough, and as he has not yet been able to compile the results of his work, it would be premature to give extracts from his monthly diaries. He has, however, sent in a short report on the Kangra slate quarries which is being published, see page 19.

Mr. Hayden proceeded to Spiti early in June 1901 in order to complete the survey of that area, which had been interrupted since 1899, and he has now brought up the task to a certain degree of completeness. This will form the subject of a memoir now being prepared by Mr. Hayden in which he was to have been assisted by the late Dr. von Krafft, who had accompanied him to Spiti in 1899 and had worked out the mesozoic rocks in considerable detail, but whose sad death in the autumn of last year has deprived us of much of the fruit of his valuable and conscientious work.

During the past season Mr. Hayden devoted most of his time to working out the palæozoic rocks of Spiti and Kanaur.

Further collections which were made from the silurian beds underlying the white (Muth) quartzite, have added considerably to our knowledge of the extent of this system, which appears to embrace the whole of the series found in Spiti between the base of the red quartzite and the base of the white (Muth) quartzite, specimens of *Pentamerus oblongus*, Sow., having been found in the silicious limestone immediately underlying the latter bed.

In Kanaur the system of limestone, shale and quartzite, so well exposed between the Lipakaw and Yulang rivers, was examined in greater detail than had hitherto been possible and large collections of fossils

were made. These have been partly worked out, and have been found to include numerous widely distributed carboniferous types, such as *Syringothyris cuspidata*, Mart., *Athyris roysii*, Leo., *Strophomena analoga*, Phill., *Athyris subtilita*, Hall, *Rhynchonella pleurodon*, var. *davrenxiana*, Kon., *Reticularia lineata*, Mart., *Productus semireticulatus*, Mart., *Productus cora*, d'Orb., *Chonetes hardrensis*, Phill., and many other forms.

Further collections were also made from the permian beds near Po, in Spiti, but these have not yet been worked out. While in Spiti, Mr. Hayden's attention was drawn by the late Dr. von Krafft to the fact that the triassic horizon of *Rhynchonella griesbachi*, Bittner, had not been identified in Spiti, though large collections had been made from it in the eastern Himalayas. A careful search proved that the species occurs also in Spiti, but fossils are extremely rare; several specimens, however, of *Rh. griesbachi* were obtained. This horizon had hitherto been looked upon as the base of the muschelkalk, but Mr. Hayden has now found both in and above it ammonites of lower triassic age, and this view must therefore be modified.

During the search for the horizon of *Rhynchonella griesbachi*, a bed was found some few feet lower down containing numerous specimens of *Pseudomonotis himaica*, Bittner. The relative positions of these two horizons had not hitherto been known with any certainty, but these have now been definitely ascertained.

## 6.—Baluchistan.

Mr. Vredenburg remained in Baluchistan up to the end of September 1901, after which he returned to Calcutta to classify his extensive collections of rocks, minerals and fossils, the result of nearly a whole year's field-work.

A short notice appeared in the last "General Report" dealing with the work performed in the Nushki desert up to March 1901. April and May were spent in mapping the tertiary igneous intrusions of the Khwāja-Amrán, mostly granites and diorites. The rest of the season was occupied in the detailed mapping of the upper Zhoō and some adjoining areas of the Pishin district, thus filling up the largest gap that still remained in the geological map of eastern Baluchistan, as many parts of that area were either completely unknown or had been visited only during rapid traverses. Last year's survey

has yielded some very interesting results, foremost amongst which may be mentioned the delineation of a large outcrop of upper trias. The rocks of that age consist of a system of shales converted by cleavage into slates, interbedded with narrow bands of a dark, nearly black limestone. Their outcrop, which is considerable, occupies the southern side of the upper Zhob valley. Owing to some lithological resemblance, they were formerly regarded as identical with the Kojak shales which occupy the Toba highland and its eastern continuation north of the Zhob, although Mr. Oldham, in the second edition of the Manual, had already expressed doubts as to the correctness of grouping together the rocks on either side of the Zhob valley. I myself, when surveying in Baluchistan in 1893, found numerous species of *Monotis* sp. and an ammonite, described by von Mojsisovics as *Didymites afghanicus* in the Palæontologia Indica, and this proved that Baluchistan contained horizons of the upper trias. It was not practicable to trace the origin of those fossils at that time, and I had to regard them as perhaps mere "blocs exotiques" caught up in a complex of later age. The work done by Mr. Vredenburg last year has established beyond the possibility of a doubt that the fossils were derived from the shales themselves. These fossils are scanty and poorly preserved, but widely distributed, and have been found *in situ* in every possible situation throughout the outcrop which is at least 50 miles long and in some places 12 miles broad. There must be a considerable thickness of these shales, but, as the commonest fossil is everywhere the same one, it is probable that we are in presence of a single stage of the trias, powerfully developed, and repeated many times by folding. The closely folded and crushed state of the rocks probably accounts largely for the scarcity of fossils.

Side by side with the *Monotis* bearing slates, there are some very limited outcrops of *fusulina* limestone of carboniferous or permian age which I had already noticed in 1893. The lithological sameness and great amount of disturbance conceal the nature of the contact, which is perhaps a faulted one.

Great basic and frequently serpentinised intrusive masses, partly the core of a cretaceous volcano, break through these older rocks and have been often referred to as representing the Deccan trap eruption of the Peninsula. These and the triassic rocks formed a land surface during a considerable part of the eocene period: the tertiary often begins only with the Spintangi which rests upon them either directly

or with the intervention of the upper portion of the Gházij. When these rocks rest upon the basic intrusions, the latter are found to have been converted into laterite down to a considerable depth.

In a number of localities, there intervene between the Spintangi and the lower Siwaliks, a group of variegated beds unconformable to the former and containing fossiliferous limestones in their upper portion. In consideration of their unconformable stratigraphy, as well as for lithological and palæontological reasons, Mr. Vredenburg is of opinion that these beds belong to the upper Nari. The fauna contains a number of lower Nari species, but some of the most characteristic ones are absent, while other species are identical with fossils occurring in the Gáj of Sind or the miocene of Europe. Amongst them may be mentioned *Breytia carinata*, d'Arch. and H., *Pecten favrei*, d'Arch. and H., *Trochus cognatus*, J. de C. Sow. (= *T. lucasanus*, Brongn.) all typical Gáj species in Sind, *Nerita martiniana*, Math., frequent in many oligocene and miocene strata of Europe, *Lucina columbella*, Lam., which is one of the commonest miocene form in Europe; the latter being extremely abundant in some exposures. Nummulites which are so abundant in the lower Nari are completely wanting. Dr. Noetling in common with other palæontologists is of opinion that the lower Nari formerly regarded as oligocene cannot be maintained in that formation as restricted by many geologists, but should be classed as eocene. It is not unlikely that the strata discovered in Baluchistan correspond with some of the beds which, by common assent, are regarded in Europe as true oligocene. It may be mentioned here that the true lower Nari, with its characteristic nummulites, occurs in several parts of Baluchistan. Dr. Blanford found it in the Bolan pass, and Dr. Noetling met with another outcrop in the northern Zhob. In the latter instance, in the neighbourhood of Tanishpa, Dr. Noetling also discovered a higher fossiliferous horizon without nummulites, which may belong to the miocene Gáj. It seems closely related to the group described by Mr. Vredenburg, several peculiar species being common to both.

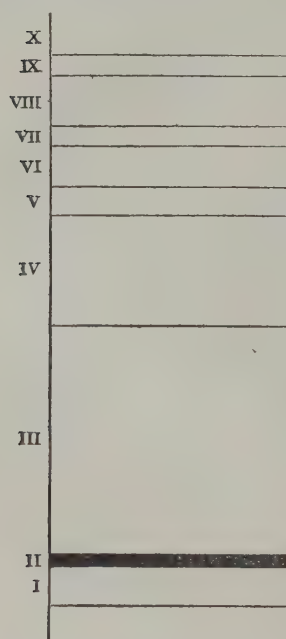
### 7.—Sind.

On his way to Baluchistan, Mr. Vredenburg spent the month of March of the present season in Sind, in continuation of some of the work performed two years ago. As a result of the study of the rich fossil collections both

Mr. Vredenburg.

from Sind and from Baluchistan preserved in the Calcutta Museum, Dr. Noetling and Mr. Vredenburg have found it necessary to introduce some further corrections in the tables of strata published in the two last "General Reports." The sequence of beds remains unaltered, but it is necessary to restore the names Ranikot and Khirthar to the position originally assigned to them by their author. The terms Ranikot and Khirthar were first employed by Dr. Blanford to designate two well-marked divisions in the eocene of Sind, the former of the two being known only in some parts of southern Sind. In many parts of Baluchistan, the eocene is easily subdivided into two groups, the Gházij and Spintangi, and it has been repeatedly suggested that this twofold division may correspond with that originally made in Sind. It is only fair to state that these suggestions were generally made in reports written in the field without any opportunity of a direct comparison of the fossils. Whenever these came to be carefully studied, the differences between the Gházij fauna and the Ranikot one became obvious, though it still remained to be proved that it was anything else but a difference of facies, and there remained a general idea that the two groups might be vicarious. The true equivalent of the Gházij had long ago been found in Sind in the richly fossiliferous shaly strata which, in the Laki range, occur near the top of the Khirthar, but, owing to the supposed identity of the Gházij and Ranikot, this group remained overlooked in all the comparisons that were made until attention was drawn to the fact by Dr. Noetling. When Dr. Noetling first came across these shales near the sulphur springs at Laki, he recognised at once their complete identity with the Gházij, and, following the accepted notion of the identity of the Gházij and Ranikot, he looked upon them as an inlier of the latter. This explains why, in the lists of strata published in the two last "General Reports," the upper limit of the Ranikot has been placed higher than it originally was by Dr. Blanford. It was only during subsequent progress of their work that Dr. Noetling and Mr. Vredenburg came across fossiliferous exposures of the true Ranikot. It then became evident that the upper limit of the Ranikot is situated several hundred feet below the Laki shales which are near the top of the Khirthar.

The following column shows the succession of strata in the Laki range, the different divisions being rendered approximately proportionate to their relative thicknesses.



I.—Shales and sandstones with some bands of limestone containing *Cardita beaumonti*, zones 2 and 3 of the previously published lists.

II.—Deccan trap, zone 4.

III.—Ranikot series, as originally defined. In the Laki range it consists almost entirely of sandstones which are either quite unfossiliferous, or contain only imperfect plant remains. At the base, resting on the Deccan trap, there frequently occurs an oyster bed, zone 5. The uppermost portion is sometimes fossiliferous, containing the new genus and species of zone 7. This curious species occurs also in the *Cardita beaumonti* beds, both in Sind and in Baluchistan.

IV.—Principal mass of the Khirthar limestone, zone 9. The fossils usually weather out as casts except in the lower-

most beds which constitute zone 8, of *Macropneustes speciosus*.

V.—Shales, clays and impure limestones, constituting zones 10 to 13 of previously published lists. Dr. Noetling has shown that these correspond with the Gházij of Baluchistan.

VI.—Limestone with large *nummulites*, uppermost part of the Khirthar, zone 14. This corresponds with the Spintangi of Baluchistan.

VII.—Mostly clays in which are intercalated some bands of dark brown richly fossiliferous nummulitic limestone, zones 15 to 17. This is the lower Nari.

VIII.—Variegated sandstones and clays, probably upper Nari.

IX.—Fossiliferous strata between the top of the variegated beds and the base of the Manchhars. Near Bagathoro the lowermost bed contains an admixture of Gáj and Nari species, together with some

peculiar species occurring in the strata regarded as upper Nari in Baluchistan and not found in any collections from the lower Nari or the typical Gáj of Sind; amongst them are *Lucina columbella* and *Nerita martiniana*. These are probably nearly of the same age as the fossiliferous beds classed as upper Nari in Baluchistan. The general appearance of the fauna recalls the presumed Gáj of Tanishpa. Above this bed, a slightly calcareous sandstone, are some limestones with typical Gáj forms such as *Echinodiscus* and large specimens of *Ostrea blanfordiana*, Noetl. Higher again comes a bed full of large specimens of *Ostrea lingua*. This bed is frequently met with at the base of the Manchhars.

X.—Base of the lower Manchhars which resemble lithologically the lower Siwaliks of Baluchistan. The lowermost beds contain vertebrate remains.

Neither the top of the Ranikot nor the base of the Khirthar are present in the above described section. It is doubtful how far the Ranikot and Khirthar are ever truly conformable, but there is an undoubted break, far more pronounced than elsewhere, in the Laki range, as was already pointed out by Dr. Blanford. Further south an important series of highly fossiliferous strata overlie zone 7 of gen. nov. spec. nov., and underlie the true Khirthar. *Nummulites* make their appearance in great abundance in these beds which, in the neighbourhood of Jhirak, contain an abundance of true *blemnites* side by side with the *nummulites*. Their mode of occurrence precludes all possibility of their being derived from an older stratum; the horizon of gen. nov. spec. nov. is not exposed at Jhirak where the lower part of the fossiliferous series is hidden beneath the Indus alluvium. At Meting, west of Jhirak, the zone 8 of *Macropneustes speciosus* is easily traceable, but it is underlaid by other Khirthar zones rich in specimens of echinoid species, none of which pass downwards into the true Ranikot. Many of the Khirthar species described in the Palæontologia Indica were obtained from the horizons underlying the zone of *Macropneustes speciosus*. Amongst the more abundant may be mentioned *Porocidaris anomala*, D. and S., *Rhynchopygus calderi*, d'A. and H., *R. pygmæus*, D. and S., *Hemiaster digonus*, d'Arch., *Metalia sowerbyi*, d'Arch. In this neighbourhood where the upper beds of the Ranikot and the lowest of the Khirthar attain their greatest thickness, the separation of the two is still well marked by a ferruginous bed of laterite, and it is doubtful whether even here there is a truly uninterrupted sequence.

One result of extreme importance is the following: it is now certain that, whilst strata of the age of the *Cardita beaumonti* beds are widely distributed in Baluchistan, the Ranikot series is absolutely unknown outside a comparatively small area of lower Sind. It is highly probable that the Ranikot beds are amongst the oldest strata yet discovered in any country that can be safely classified within the tertiary system.

An error that crept into the General Report for 1900-1901 may be corrected here. In mentioning the interesting occurrence of tertiary *belemnites* above alluded to, near Jhirak, on page 5 of that publication, the discovery was attributed to Dr. Noetling. The original finder was Mr. Vredenburg.

When passing through Karachi Mr. Oldham found an opportunity of investigating the question of the sandhills which are blocking the road from Karachi to Clifton. The growth of these sandhills has been rapid during the last few years, but no accurate data are available, a survey has now been made which will enable their progress in future to be measured. The cause of the sandhills is locally supposed to be the dumping of dredgings from the harbour of Clifton. This appears to be an unimportant factor compared with the general drift of sand along the shore; the direct cause is the closing of one of the original outlets of the Karachi harbour, known as the Chinna creek, by which the tidal scour that kept the foreshore of the Clifton cliffs free from sand has been checked. An accumulation of sand has consequently been formed which stretches out beyond the former shore line and has formed a gathering ground from which the sand has been blown inwards by the strong winds of the monsoon. There appears to be no practicable cure, for the reopening of the Chinna creek is out of the question on account of the deterioration of the harbour which would result, and the only palliation possible appears to be the encouragement of the growth of the local couch-grass.

C. L. GRIESBACH, *Director,*  
*Geological Survey of India.*

CALCUTTA:  
The 1st April 1902.

*Part 3.*—Note on the progress of the gold industry in Wynaad, Nilgiri district. Notes on the representatives of the Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.

*Part 4.*—On the geographical distribution of fossil organisms in India. Submerged forest on Bombay Island.

VOL. XII, 1879.

*Part 1.*—Annual report for 1878. Geology of Kashmir (third notice). Further notices of Siwalik mammalia. Notes on some Siwalik birds. Notes of a tour through Hangrang and Spiti. On a recent mud eruption in Ramri Island (Arakan). On Braunite, with Rhodonite, from near Nagpur, Central Provinces. Palæontological notes from the Satpura coal-basin. Statistics of coal importations into India.

*Part 2.*—On the Mohpani coal-field. On Pyrolusite with Psilomelane occurring at Gosalpur, Jabalpur district. A geological reconnaissance from the Indus at Kushalgarh to the Kurram at Thal on the Afghan frontier. Further notes on the geology of the Upper Punjab.

*Part 3.*—On the geological features of the northern part of Madura district, the Pudukota State, and the southern parts of the Tanjore and Trichinopoly districts included within the limits of sheet 80 of the Indian Atlas. Rough notes on the cretaceous fossils from Trichinopoly district, collected in 1877-78. Notes on the genus *Sphenophyllum* and other Equisetaceæ, with reference to the Indian form *Trizygia Speciosa*, Royle (*Sphenophyllum Trizygia*, Ung.). On Mysorin and Atacamite from the Nellore district. On corundum from the Khasi Hills. On the Joga neighbourhood and old mines on the Ner-budda.

*Part 4.*—On the 'Attock Slates' and their probable geological position. On a marginal bone of an undescribed tortoise, from the Upper Siwaliks, near Nila, in the Potwar, Punjab. Sketch of the geology of North Arcot district. On the continuation of the road section from Murree to Abbottabad.

VOL. XIII, 1880.

*Part 1.*—Annual report for 1879. Additional notes on the geology of the Upper Godavari basin in the neighbourhood of Sironcha. Geology of Ladak and neighbouring districts, being fourth notice of geology of Kashmir and neighbouring territories. Teeth of fossil fishes from Ramri Island and the Punjab. Note on the fossil genera *Nöggerathia*, Stbg., *Nöggerathiopsis*, Fstm., and *Rhoptozamites*, Schmalh., in palæozoic and secondary rocks of Europe, Asia, and Australia. Notes on fossil plants from Kattywar, Shekh Budin, and Sirgujah. On volcanic foci of eruption in the Konkan.

*Part 2.*—Geological notes. Palæontological notes on the lower trias of the Himalayas. On the artesian wells at Pondicherry, and the possibility of finding such sources of water-supply at Madras.

*Part 3.*—The Kumaun lakes. On the discovery of a celt of palæolithic type in the Punjab. Palæontological notes from the Karharbari and South Rewah coal-fields. Further notes on the correlation of the Gondwana flora with other floras. Additional note on the artesian wells at Pondicherry. Salt in Rajputana. Record of gas and mud eruptions on the Arakan coast on 12th March 1879 and in June 1843.

*Part 4.*—On some pleistocene deposits of the Northern Punjab, and the evidence they afford of an extreme climate during a portion of that period. Useful minerals of the Arvali region. Further notes on the correlation of the Gondwana flora with that of the Australian coal-bearing system. Note on reh or alkali soils and saline well waters. The reh soils of Upper India. Note on the Naini Tal landslide, 18th September 1880.

VOL. XIV, 1881.

*Part 1.*—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts, being fifth notice of the geology of Kashmir and neighbouring territories. Note on some Siwalik carnivora. The Siwalik group of the Sub-Himalayan region. On the South Rewah Gondwana basin. On the ferruginous beds associated with the basaltic rocks of north-eastern Ulster, in relation to Indian laterite. On some Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on the lower trias of the Himalayas.' On some mammalian fossils from Perim Island, in the collection of the Bombay Branch of the Royal Asiatic Society.

- Part 2.**—The Nahan-Siwalik unconformity in the North-western Himalaya. On some Gondwana vertebrates. On the ossiferous beds of Hundes in Tibet. Notes on mining records, and the mining record office of Great Britain; and the Coal and Metalliferous Mines Acts of 1872 (England). On cobaltite and danaite from the Khetri mines, Rajputana; with some remarks on Jaipurite (Syepoorite). On the occurrence of zinc ore (Smithsonite and Blende) with barytes, in the Karnul district, Madras. Notice of a mud eruption in the island of Cheduba.
- Part 3.**—Artesian borings in India. On oligoclase granite at Wangtu on the Sutlej, North-west Himalayas. On a fish-palate from the Siwaliks. Palæontological notes from the Hazaribagh and Lohardagga districts. Undescribed fossil carnivora from the Siwalik hills in the collection of the British Museum.
- Part 4.**—Remarks on the unification of geological nomenclature and cartography. On the geology of the Arvali region, central and eastern. On a specimen of native antimony obtained at Pulo Obin, near Singapore. On Turgite from the neighbourhood of Juggia-pett, Kistnah district, and on zinc carbonate from Karnul, Madras. Note on the section from Dalhousie to Pangri, *via* the Sach Pass. On the South Rewah Gondwana basin. Submerged forest on Bombay Island.

VOL. XV, 1882.

- Part 1.**—Annual report for 1881. Geology of North-west Kashmir and Khagan (being sixth notice of geology of Kashmir and neighbouring territories). On some Gondwana labyrinthodonts. On some Siwalik and Jamna mammals. The geology of Dalhousie, North-west Himalaya. On remains of palm leaves from the (tertiary) Murree and Kasauli beds in India. On Iridosmine from the Noa-Dibing river, Upper Assam, and on Platinum from Chutia Nagpur. On (1) a copper mine lately opened near Yongri hill, in the Darjiling district; (2) arsenical pyrites in the same neighbourhood; (3) kaolin at Darjiling (being 3rd appendix to a report on the geology and mineral resources of the Darjiling district and the Western Duars). Analyses of coal and fire-clay from the Makum coal-field, Upper Assam. Experiments on the coal of Pind Dadun Khan, Salt-range, with reference to the production of gas, made April 29th, 1881. Report on the proceedings and result of the International Geological Congress of Bologna.
- Part 2.**—General sketch of the geology of the Travancore State. The Warkilli beds and reported associated deposits at Quilon, in Travancore. Note on some Siwalik and Narbada fossils. On the Coal-bearing rocks of the valleys of the Upper Rer and the Mand rivers in Western Chutia Nagpur. On the Pench river coal-field in Chhindwara district, Central Provinces. On borings for coal at Engsein, British Burma. On sapphires recently discovered in the North-west Himalaya. Notice of a recent eruption from one of the mud volcanoes in Cheduba.
- Part 3.**—Note on the coal of Mach (Much) in the Bolan Pass, and of Sharag or Sharigh on the Harnai route between Sibi and Quetta. New faces observed on crystals of stilbite from the Western Ghâts, Bombay. On the traps of Darang and Mandi in the North-western Himalayas. Further note on the connexion between the Hazara and the Kashmir series. On the Umaria coal-field (South Rewah Gondwana basin). The Daranggiri coal-field, Garo Hills, Assam. On the outcrops of coal in the Myanounng division of the Henzada district.
- Part 4.**—On a traverse across some gold-fields of Mysore. Record of borings for coal at Beddadanol, Godavari district, in 1874. Note on the supposed occurrence of coal on the Kistna.

VOL. XVI, 1883.

- Part 1.**—Annual report for 1882. On the genus *Richthofenia*, Kays (*Anomia Lawrenceana*, Koninck). On the geology of South Travancore. On the geology of Chamba. On the basalts of Bombay.
- Part 2.**—Synopsis of the fossil vertebrata of India. On the Bijori Labyrinthodont. On a skull of *Hippotherium antilopinum*. On the iron ores, and subsidiary materials for the manufacture of iron, in the north-eastern part of the Jabalpur district. On laterite and other manganese ore occurring at Gosulpore, Jabalpur district. Further notes on the Umaria coal-field.
- Part 3.**—On the microscopic structure of some Dalhousie rocks. On the lavas of Aden. On the probable occurrence of Siwalik strata in China and Japan. On the occurrence of *Mastodon angustidens* in India. On a traverse between Almora and Mussooree made in October 1882. On the cretaceous coal-measures at Borsora, in the Khasia Hills, near Laour, in Sylhet.

*Part 4.*—Palæontological notes from the Daltonganj and Hutar coal-fields in Chota Nagpur. On the altered basalts of the Dalhousie region in the North-western Himalayas. On the microscopic structure of some Sub-Himalayan rocks of tertiary age. On the geology of Jaunsar and the Lower Himalayas. On a traverse through the Eastern Khasia, Jaintia, and North Cachar Hills. On native lead from Maulmain and chromite from the Andaman Islands. Notice of a fiery eruption from one of the mud volcanoes of Cheduba Island, Arakan. Notice.—Irrigation from wells in the North-Western Provinces and Oudh.

Vol. XVII, 1884.

*Part 1.*—Annual report for 1883. Considerations on the smooth-water anchorages or mud banks of Narrakal and Alleppy on the Travancore coast. Rough notes on Billa Surgam and other caves in the Kurnool district. On the geology of the Chuari and Sihunta parganas of Chamba. On the occurrence of the genus *Lyttonia*, Waagen, in the Kuling series of Kashmir.

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FOR THE PERIOD FROM THE 1ST APRIL

1900

TO THE 31ST MARCH

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UNDER THE DIRECTION OF

C. L. GRIESBACH, C.I.E., F.G.S.



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#### DIRECTOR.

C. L. GRIESBACH, C.I.E., F.G.S.

#### SUPERINTENDENTS.

1. R. D. OLDHAM, A.R.S.M., F.G.S., on furlough from 11th July 1899.
2. TOM D. LATOUCHE, B.A.
3. C. S. MIDDLEMISS, B.A., on furlough from 16th June 1900.

#### DEPUTY SUPERINTENDENTS.

1. P. N. BOSE, B.Sc. (London), F.G.S.
2. T. H. HOLLAND, A.R.C.S., F.G.S., also Curator up to 18th March 1901, and Officiating Superintendent *vice* Mr. Oldham from 6th July 1899.
3. P. N. DATTA, B.Sc. (London), F.G.S., also Officiating Superintendent *vice* Mr. Middlemiss from the 7th June 1900.
4. F. H. SMITH, A.R.C.S., on furlough from 10th May 1900.

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## ASSISTANT SUPERINTENDENTS.

1. H. H. HAYDEN, B.A., B.E., on privilege leave from 29th June to 11th October 1900. Officiating Deputy Superintendent from 6th July 1899 *vice* Mr. T. H. Holland, also Curator from 19th March 1901 *vice* Mr. T. H. Holland.
2. E. VREDENBURG, B.L., B.Sc. (Paris), A.R.C.S., on privilege leave from 28th August to 13th December 1900. Also Officiating Deputy Superintendent *vice* Mr. Smith from 9th May 1900.
3. T. L. WALKER, M.A. (Kingston), Ph.D. (Leipzig), on privilege leave from 2nd July to the 11th October 1900. Also Officiating Deputy Superintendent *vice* Mr. P. N. Datta from 7th June 1900.
4. A. KRAFFT von Dellmensingen, Ph.D. (Vienna). Confirmed in the grade from 13th January 1899.

## PALÆONTOLOGIST.

FRITZ NOETLING, Ph. D. (Berlin), F.G.S.

## SPECIALISTS.

1. G. A. STONIER, A.R.S.M., F.G.S., also Officiating Inspector of Mines in India *vice* Mr. Grundy from 13th March 1901.
2. G. F. READER, F.G.S., also Officiating Inspector of Mines in India *vice* Mr. Grundy from 3rd October 1900. Died at Madras from Cholera on 12th March 1901.
3. F. H. HATCH, Ph.D., A.M.I.C.E., F.G.S. Completed period of service on 14th March 1901.

## SUB-ASSISTANTS.

1. HIRA LAL.
2. KISHEN SINGH, F.G.S.

## ARTIST.

H. B. W. GARRICK.

## ASSISTANT CURATOR.

T. R. BLYTH. Appointed Assistant Curator from 13th February 1901.

## REGISTRAR.

A. E. MacA. AUDSLEY.

## INSPECTOR OF MINES IN INDIA.

JAMES GRUNDY. On leave on Medical Certificate from the 2nd October 1900.

# GENERAL REPORT

ON THE WORK CARRIED ON BY THE

## GEOLOGICAL SURVEY OF INDIA

FOR THE PERIOD FROM THE 1ST APRIL

1900

TO THE 31ST MARCH

1901.

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### PART I.—HEAD-QUARTER NOTES.

*Director's Tours.* During the twelve months under report, I carried out the following tours:—

- (1) During July to Darjeeling accompanied by Mr. T. H. Holland, to examine with a Committee of Engineers the landslip which occurred on the 15th of that month.
- (2) From the 13th October to the 24th November to the Madras Presidency. The object of this tour was the inspection of the work carried on in the Wainád district and Mysore by Messrs. Hayden and Stonier and Dr. Hatch, respectively.

#### 1.—Museum and Laboratory.

Mr. T. H. Holland was in charge of the Curator's office the entire twelve months, and has been single-handed throughout the year owing to the absence of the Museum Assistant in Paris. The work of determining specimens

sent to head-quarters has, however, been kept up to date and a satisfactory amount of progress made in the *Museum work.* Amongst the specimens of interest, which have been acquired during the year, we are indebted to the Trustees of the British Museum for a set of duplicates of rock specimens collected in the Transvaal by Dr. F. H. Hatch. They are of value to us on account of the similarity which has been known in a general way to exist between the South African rocks and some of the older unfossiliferous formations of Peninsular India.

To the continued interest of a previous Superintendent and Curator, Mr. F. R. Mallet, we are indebted for a donation of artificial langbeinite, and an interesting series of American specimens, including the remarkable rock, topaz-rhyolite, and the mineral plattnerite.

The Mysore Geological Department has presented a specimen of a remarkable rock which was found by *Mysore rocks.* Mr. Holland when on deputation in the Mysore State in 1898, and has been made the subject of a special study, of which an account will shortly appear in the Memoirs.

Amongst the collections made by the survey officers during the year, a series of gold-bearing quartz specimens and associated rocks was obtained by Dr. F. H. Hatch in the Kolar gold-field, their descriptions being published as an appendix to his memoir on the latter.

Whilst examining some specimens from the neighbourhood of the Raniganj coal-field, Mr. Holland detected *Raniganj rocks.* rocks similar to the well-known anorthosites of Canada, and subsequently, in company with Mr. E. Seymour Wood of the Bengal Coal Company, verified the existence of the series on the south bank of the Damuda river. These rocks form a very interesting addition to the hypersthene-bearing members which are so remarkably abundant amongst the Peninsular crystallines.

The Paris Exhibition, at which this Department was represented by a fine series of rocks and minerals illustrating the economic geology of India, closed on *Paris Exhibition.* the 15th November 1900, and the collections, which were throughout under the charge of Mr. T. R. Blyth, the Assistant Curator of the Geological Museum, were at once packed and returned to India. A certain number of specimens, of which we possess many duplicates, were presented to institutions and museums in Europe. The exhibition awarded the Grand Prix with gold medal to the Department, whilst several private contributors to the exhibits of the

Geological Survey received silver medals, and Mr. Blyth was granted a special gold medal.

Mr. Blyth rejoined the department from deputation on the 7th March 1901.

## 2.—Palæontological work.

A very large number of fossils were collected during the year, in Sind, the Salt range and Himálayas by  
*Collections.* Drs. Noetling and von Krafft, and in Burma by Messrs. La Touche and Datta.

### (a) Descriptive work in India.

Dr. F. Noetling was engaged during the cold season of 1900-1901, in editing his description of the Miocene  
*Tertiary fossils of Sind.* fossils of Burma, and in determining the large collections of tertiary fossils which he had obtained during the preceding field season in Sind. Most of the time was devoted to the study of the fossils of the Nari beds of the neighbourhood of Lakki, which Dr. Noetling identifies as the zone of *Cerithium sp. Expatagus rostratus*, d'Arch., and *Echinolampas discoideus*, Dun.

An interesting discovery is that of the occurrence of true Belemnites, which Dr. Noetling found in great numbers in lower eocene beds near Jhirrak in Sind.

Dr. von Krafft continued the description of the lower trias fossils from the Himálayas and he has adopted  
*DR. VON KRAFFT on the trias of the Himálayas.* Dr. Noetling's views<sup>1</sup> with regard to the age of the lower Otoceras beds. The collections of lower trias fossils, which he is describing, have largely increased since the cold season of 1899 to 1900, Dr. Noetling having brought many specimens from the Shalshal cliff, while Dr. Krafft himself found red limestones with lower triassic *Cephalopoda* among the "exotic blocks" of Johar. For this reason the material, worked out previously, had to be re-examined. The most prominent genus, *Meekoceras*, with 26 species, is now fully described, the rest is partly worked out and will, it is hoped, be finished in a few months.

<sup>1</sup> See page 28 of this report.

The limestones above the "Productus shales" include five different faunas, following each other in descending order as follows :—

Horizon of *Sibirites*, sp.

- " „ *Flemingites rohilla*.
- " „ *Meekoceras*, n. sp.
- " „ *Ophiceras sakuntala*.
- " „ *Otoceras woodwardi*.

Of these the lowest one should be included in the permian. This appears indicated owing to *Medlicottia dalailamæ* being indistinguishable from *M. wynnei* of the upper productus limestone of the Salt range and also owing to the fact that *Xenaspis carbonaria* and *Cyclolobus oldhami*, both species of the uppermost middle productus limestone,<sup>1</sup> occur only 20 to 30 feet below the layer with *Otoceras*. Whether the horizon of *Ophiceras sakuntala* is triassic or not, cannot be decided so far, but the horizon of *Meekoceras* nov. sp., certainly is. The horizon of *Sibirites*, n. sp. unfortunately represented by a few fossils only, was discovered among Mr. Smith's Byans collections, had so far been unknown from the Himalayas. It corresponds to the upper Ceratite limestone of the Salt range (zone of *Stephanites superbus*).

(b) Descriptive work in Europe.

As in previous years the Department received assistance from European Palæontologists, who described several of our collections for publication in the *Palæontologia Indica*. The following gentlemen were at work during the year :—

In England—

DR. F. L. KITCHIN, F.G.S.,	} Jurassic	<i>Lamellibranchiata</i>
Geological Survey of England and Wales.		
	} of Cutch.	

<sup>1</sup> General Report, 1899-1900, p. 182. *Cyclolobus oldhami* was found by Waagen together with *Xenaspis carbonaria*. Pal. Ind., Ser. XIII, Vol. I, p. 37.

*In Austria—*

PROF. DR. UHLIG,  
University of Vienna.

} Jurassic fossils of the Himá-  
layas.

*In France—*

PROF. R. ZEILLER,  
École Nationale Supérieure  
des Mines.

} Gondwana Fossils.

Professor E. Suess has again taken upon himself the responsible task of superintending the work done in Austria, and he arranged for the publication of the plates which are to illustrate the reports. Dr. Henry Woodward, F.R.S., Keeper of the Geological Department of the British Museum (Natural History), has promised similar assistance with respect to the palæozoic collections of the Himálayas, but up to date it has been impossible to find an English Palæontologist to take up this particular series of fossils. Dr. W. T. Blanford, F.R.S., has also rendered valuable assistance in this direction, and has generally superintended the work done in England for the Department.

### 3.—Publications.

The following publications were issued during the past twelve months:—

General Report on the work carried on by the Geological Survey  
*General Report.* of India from the 1st April 1899 to the 31st  
March 1900.

Memoirs, Vol. XXVIII, pt. 2.—The Charnockite Series, by T. H.  
*Memoirs.* Holland, on the 13th August 1900.

Ditto Vol. XXX, pt. 1.—List of Aftershocks of the Great  
Earthquake of 12th June 1897, by R. D.  
Oldham, on the 6th April 1900.

Ditto ditto, pt. 2.—Geology of the Neighbourhood of  
Salem, Madras Presidency, by T. H. Holland,  
on the 6th December 1900.

Memoirs, XXXIII, pt. 1.—The Kolar Gold-field, by F. H. Hatch, on the 7th March 1901.

Palæontologia Indica, Series IX, Vol. II, pt. 2.—Corals of Cutch, by J. W. Gregory, on the 13th July 1900.

Ditto Series IX, Vol. III, pt. 1.—Brachiopoda of Cutch, by F.L. Kitchen, on the 28th September 1900.

Ditto Series XV, Vol. III, pt. 2.—Trias Brachiopoda, by Dr. Bittner, on the 13th July 1900.

Owing to the illness of Mr. J. Grundy, the Inspector of Mines, his report for the calendar year 1899 had to be compiled by Mr. G. F. Reader, and was delayed until February 1901.

*Report of the Inspector of Mines.*

The additions to the library, during the year 1900 to 1901, amount to 2,146 volumes, of which 917 were acquired by presentation and 1,229 by purchase.

*Library.*

## PART II.—FIELD PARTIES.

During the year ending the 31st March 1901 the officers of the Department were distributed as follows :—

*Distribution of officers.*

### SUPERINTENDENTS.

Mr. T. H. D. LaTouche	.	At head-quarters until the 14th October 1900; then in Madras Presidency in connection with the water-supply of Guntur, and afterwards in northern Shan States.
„ C. S. Middlemiss	.	At head-quarters until 7th June 1900; then furlough for 18 months.

## DEPUTY SUPERINTENDENTS.

Mr. P. N. Bose . .	At head-quarters until 10th October 1900; then Assam.
„ T. H. Holland . .	At head-quarters until 18th March 1901; then Punjab. On short deputation to investigate Darjeeling landslip during July 1900.
„ P. N. Datta . .	At head-quarters until 16th October 1900; then northern Shan States.
„ F. H. Smith . .	Head-quarters till 18th May 1900; then furlough for 18 months.

## ASSISTANT SUPERINTENDENTS.

Mr. H. H. Hayden . .	Head-quarters till 15th May 1900; then in the Wainád District.
„ E. Vredenburg . .	At head-quarters during the rainy season; posted to Baluchistan from the 13th November 1900.
Dr. T. L. Walker . .	At head-quarters until 26th October 1900; then in the Vizagapatam District.
„ A. von Krafft . .	In Kumaon till 16th October 1900; then at head-quarters.

## PALÆONTOLOGIST.

Dr. Fritz Noetling . .	Head-quarters up to 16th June 1900; afterwards Gharwal Himálayas; returned on the 26th October, and remained at head-quarters till February 1901; proceeded to northern Shan States.
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## SPECIALISTS.

Mr. G. A. Stonier . . .	In the Wuntho District, Burma, till 3rd June 1900; at head-quarters, Calcutta, from the 4th to 25th June 1900; then in the Wainád District, Madras, till 7th November 1900; afterwards in the Jherria coal-field, Bengal.
„ G. F. Reader . . .	At head-quarters till 4th October 1900, when he was appointed officiating Inspector of Mines, and engaged in numerous inspections till 12th March 1901, on which date he died when on tour.
Dr. F. H. Hatch . . .	Hyderabad, Deccan, Mysore and the Wainád District, Madras; head-quarters and short tour in Bengal.

## SUB-ASSISTANTS.

Lala Hira Lal . . .	Head-quarters, Museum.
„ Kishen Singh . . .	Wuntho District, Burma, and the Wainád, Madras.

## ASSISTANT CURATOR.

Mr. T. R. Blyth . . .	On deputation to Paris in charge of exhibits; returned to head-quarters 7th March 1901.
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The surveys, as far as practicable, were divided into purely  
*Division of work.* scientific and economic inquiries.

## A.—ECONOMIC ENQUIRIES.

## 1.—Gold.

*Burma.*

The investigations in the auriferous area of the Wuntho District were continued during the hot weather of 1900 until the heavy rains set in which stopped field work in June.

The most important fact ascertained during the latter part of the investigations in Wuntho, appears to be the occurrence of gold in cupriferous quartz-reefs, which are found in the granitic area north of Baumauk. A reef which has been specially reported on is said to contain 9 dwts. of gold to the ton of quartz. The fact is important, as it was hitherto believed that, at least in the Chouk-pazat and Wuntho areas, quartz-reefs in granite are generally non-auriferous.

*Wainád.*

As the result of a preliminary survey of the more important quartz-veins of the south and south-east Wainád,<sup>1</sup> which Mr. Hayden made last year, it was decided to submit two of the mines that had been opened out during the mining activity of the early eighties to a detailed examination with a view to determining once for all, whether with the improved appliances and perfected processes of modern gold-recovery, there might be any chance for profitable gold-mining in this district. Mr. Hayden's researches led him to the conclusion that the two properties most suitable for such an examination were those known as the "Alpha" and the "Phoenix" for the reasons:—firstly, that extensive drives on the course of the vein were known to exist in both these mines, so that it would be possible, if they were made accessible, to institute a thorough sampling of the ore-bodies and thus to arrive at a fair approximation of the average value and stoping width of the ore; secondly, that these mines were credited by rumour with being capable of better results than had been obtained when they were formerly worked, if more efficient methods and better machinery were to be used.

<sup>1</sup> See General Report of the Geological Survey of India, 1899-1900, p. 53.

These two mines having been selected, it remained to render them accessible for sampling, and in order to do this a considerable amount of preliminary work was necessary to clear away the débris that, falling from the soft decomposed walls of the vein, had been washed down the stopes, and had gradually silted up the tunnels, in some cases partially, in others completely. The back of the drives had also to be supported in many dangerous places by close timbering. This task which exacted considerable care and constant supervision, in order to prevent the occurrence of accidents to the native workmen, was carried out under the direction of Messrs. Hayden and Stonier, assisted by Lala Kishen Singh, to whom every credit is due for the success which crowned their effort.

Dr. Hatch did the systematic sampling of the ore-bodies laid bare. Every ten feet, along the whole length of vein exposed, samples were taken across the whole width of vein at the marked points. These samples, in all 267, were then carefully assayed and in addition a large number of special samples of pyritic patches, richer in gold, were taken and concentrates of these patches also assayed.

Dr. Hatch has now come to the conclusion that "there can be no doubt after the careful and systematic sampling of the two mines, as to the unpayability of the ore-bodies that have been opened up by the Alpha and Phoenix workings; and the present developments are in my opinion sufficient to justify a condemnation of the veins on which these mines have been opened. If the presence of chutes of pay-ore could have been established, even though of small extent, there might have been some encouragement for the undertaking of further prospecting operations; but with the results rehearsed on the preceding pages<sup>1</sup> such a course cannot be recommended."

#### *Chota Nagpur.*

At the end of his deputation to the Wainád and before terminating his engagement on this Department,  
DR. F. H. HATCH, Dr. Hatch was deputed to examine one of the auriferous reefs belonging to the Pahardiah Gold Mining Company (formerly the Bengal Gold and Silver Mining Company). The property is situated at Pahardiah near the village of Somij in the Singhboom district of Chota Nagpur.

<sup>1</sup> Of his report, now in the press.

Dr. Hatch has submitted a report on this locality, which will be published in the Memoirs, Vol. XXXIII.

There has been some development done on the so-called "veins," which are in reality beds of quartzite which are associated with a series of calc-chlorite schists, the whole constituting a part of the great group of transition rocks. A number of samples of the ore-body have been taken and assays made; these gave as results the following yield in pennyweights of fine gold to the ton of ore: dwts. 4'5, 3'25, 1'3, 2, 7'8, 5'2. These results are sufficiently encouraging to warrant some money being spent on the further development of the "veins," which are from 3 to 12 feet in thickness, and seemingly of great lengths.

### *Mysore.*

During the rainy season of last year, when camping out was impossible in Bengal or in the Wainád, Dr. Hatch was deputed to the Kolar Gold-fields to make a complete study of the occurrence of the gold of that area and of the methods adopted of gold-recovery, which he has very ably carried out, and his experiences are embodied in his report in Memoirs, Vol. XXXIII, pt. 1, which has already been published.

### 2.—Coal.

In connection with the Jherria coal-field railway survey Mr. Stonier was engaged during the entire cold weather season in making detailed studies of certain coal-seams of that field, in which he was assisted by Lala Kishen Singh and Hira Lal during the end of the season. The task is not completed yet and the results will depend on several drills which are now being executed.

### 3.—Miscellaneous Minerals.

At the request of the Government of Bombay, Mr. Vredenburg was sent to examine certain tracts in the Jambughoda district of the Panch Mahals, where it was supposed that tin ore exists, besides other valuable minerals.

MR. VREDENBURG.  
*Panch Mahals.*

None of the minerals supposed to exist in the Panch Mahals were met with, although

*Tin ore.*  
Mr. Vredenburg was accompanied by the person who pretended

to have found them originally, and the supposed tin ores were found to be hæmatite only.

At the conclusion of this task, Mr. Vredenburg visited the Kishengarh State, to report chiefly on the copper ores and mica found there, which are somewhat promising. He has furnished a report.

*Copper and Mica,  
Kishengarh in Rajputana.*

Dr. T. L. Walker discovered several localities in the north-eastern portion of the Kalahandi State where graphite is met with in parallel bands or veins, and apparently of good quality.

*Graphite. Kalahandi  
State, Central Provinces.*

Mr. Bose reports on thin seams of coal which he met two or three miles south of Jowai in the hill tract south-east of Shillong in Assam. He also mentions a locality in the Khasimara valley where petroleum in small quantities oozes out of tertiary sandstone.

*Coal and Petroleum,  
south-east of Shillong.*

#### 4.—Water-Supply.

Several inquiries were addressed to the Department with reference to water-supply, either artesian or otherwise, and officers of the department were deputed to study the local conditions, where the water-supply was required, and furnished reports on the same. In this manner Mr. Hayden examined during May 1900 a site for a dam to be built in connection with a water-supply scheme near the Kartéri falls in the Nilgiris and reported on the locality. Mr. La Touche inspected the proposed water-supply schemes of Guntur in Madras and the artesian boring in Place's Garden in Madras during October 1900.

MESSRS. LA TOUCHE,  
HAYDEN AND VREDEN-  
BURG.

A very important compilation on the "Recent artesian experiments in India" from 1883 to the present day has been completed by Mr. E. Vredenburg, and is about to issue in *Memoirs*, Vol. XXXII.

#### 5.—Landslips.

During July 1900 I visited Darjeeling accompanied by Mr. Holland and examined, with a committee of engineers, the landslip which fell into the Limbu Jhora on the 15th of that month. Mr. Holland subsequently furnished a

THE DIRECTOR AND  
MR. T. H. HOLLAND.

full report. The landslide was evidently caused by rain saturation on a slope already lying outside the safe angle. Subsequent development has shown that the movement in the north-western direction has been facilitated by the existence of a highly inclined fold-fault plane along which water has freely percolated, softened the rocks and introduced a layer of fine clay, which when wetted acted as a lubricant between the sliding and the fixed masses.

During the latter half of March Mr. T. H. Holland examined, at the request of the Punjab Government, a serious landslide which occurred last year below the jail at Dharmsala, and he made a general survey of the slopes around the station. In the case of the slip near the Dharmsala jail, a large mass of detritus extending some 500 yards along the face of the hill has moved out at an unusually low slope of less than  $23^{\circ}$ . The spur on which the jail is built consists entirely of river detritus, and the slip which has taken place is not a mere surface fall, but a well-defined river-like movement of a deep mass, showing the usual phenomena of fissures in its upper section (*Abrissgebiet*) and the fan-shaped protuberant masses below (*Ab-lagerungs Gebiet*). The angle of slope is well below the angle of repose of the detritus under ordinary conditions of partial wetting, and the slip is evidently due to excessive saturation by water. The premonitory symptoms of the slip were well pronounced in August of last year, and the final fall occurred on the 28th of September at the end of a very heavy monsoon. The rain which fell during the monsoon was given every ordinary opportunity of soaking into the hill, as not a single building in the jail or police lines is supplied with a gutter for its roof, and no water-tight drains of any sort exist in the compound or on the hill-side. In addition to the water which so entered the hill with each fall of rain, a *katcha kúl*, carrying a large stream of water was, until this year, carried along the brow of the hill, almost coincident with the upper limiting fissures of the slip. In addition, therefore, to the facilities offered naturally by the very porous character of the detritus composing the spur, the local authorities added very material assistance to the agencies which brought about the slip. Although the jail buildings are seriously cracked, Mr. Holland thinks that the recognition of the true cause of the slip will give the remedial measures, which are promptly being undertaken, the effect of rendering the jail compound perfectly safe. The lesson, it is hoped, will be applied

MR. HOLLAND,  
Dharmasala, Punjab.

to the rest of the station, in many parts of which movements have occurred on slopes well below the angle of safety under conditions of ordinary drainage, and are due to the general want of system in drainage, as well as to the practice of conducting long distance *kúls* in *katcha* channels.

## 6.—Inspection of Mines.

The Inspector of Mines in India, Mr. James Grundy, proceeded on sick leave on the 3rd October 1900 and  
 MR. JAMES GRUNDY, on sick leave on the 3rd October 1900 and  
 „ G. F. READER. Mr. G. F. Reader was appointed to officiate for  
 „ G. A. STONIER. him. Unfortunately this officer, who had shown much ability during the short period of his activity, died on the 12th March of this year whilst on inspection duty in Madras. Mr. G. A. Stonier has since been appointed to officiate as Chief Inspector of Mines in addition to his other duties.

## B.—GEOLOGICAL SURVEYS.

### 1.—Madras Presidency.

During the months of October 1900 to the end of December Dr. Walker was engaged in geologically surveying the Nowrangapur taluq in the Vizagapatam district. The geological results may be stated as follows:—  
 DR. T. L. WALKER.

*Crystalline schists* are the chief rocks and cover the whole of the taluq, except that occupied by a few small patches of Cuddapah rocks. The schists are principally biotite and hornblende granitoid gneisses, amphibolite and subordinate quartzite bands. The general strike is north-west, but there are few good exposures except in the extreme north-eastern part of the taluq beyond the Tel river.  
*Vizagapatam District.*

*The Cuddapah System* is represented by two fairly large outliers and a number of small ones, the latter being chiefly small isolated hills where these rocks form caps on the gneiss. The largest of the outliers occupies the valley of the Indrabati from Nowrangapur westward to the Bastar boundary. The northern boundary of the

Cuddapah outcrop is probably faulted since the quartzites along the north dip from  $30^{\circ}$  to  $50^{\circ}$  south-west away from the gneisses, while the rocks are in all other exposures almost horizontal. The quartzites are apparently the oldest rocks of the system exposed. Buff concretionary limestone, resembling some of the limestones of Dr. William King's Cheyair group, and purple slates, are the upper members of the system.

The second Cuddapah outlier of importance occupies the little plateau east of Chocha, and extends along the Kalahandi boundary from N. Lat.  $19^{\circ}33'$  to N. Lat.  $19^{\circ}50'$ . In this outcrop, however, the concretionary limestone has not been observed.

Decomposed diabase and laterite are occasionally seen in small exposures.

## 2.—Central Provinces.

Since the beginning of 1901 Dr. Walker was engaged in making a geological reconnaissance of Kalahandi State where the rocks shew much greater variety and give promise of very valuable mineral products. Besides a very small outcrop of Talchir

DR. T. L. WALKER  
Kalahandi State,  
Central Provinces.

sandstone in the extreme northern point of the State, there are five well-defined rock systems which form more or less parallel belts, stretching north-north-east and south-south-east. At present Dr. Walker is not prepared to state the relative ages of these systems of crystalline rocks.

*Cuddapah system.*—These rocks form the most western of the five belts referred to, and are only a continuation of the second of the Cuddapah outliers referred to above. They make up the high ridge along the Jeypore boundary and are chiefly dirty white quartzites and drab slates.

*Crystalline complex.*—This group of rocks covers the larger part of the north-western half of the State, and extends east to within five miles of Bandesor. Hornblende biotite gneiss, at times augitic, is the most prominent rock. The usual strike is north and south.

*Garnetiferous granitoid gneiss* forms a belt from ten to twelve miles wide and extends from Bandesor north to the Tel river.

*Garnet quartz sillimanite schists* form most of the hills along

the Ganjam frontier and the northern margin of the hills south and east of Bandesor. They frequently contain graphite and are usually foliated. The strike varies from north-north-west to north-north-east.

*Charnockite* forms the greater part of the hill ranges in the south-eastern part of the State. This is merely a continuation of the great Charnockite massif discovered last year in the agency tracts of Vizagapatam. This great rock mass probably extends from the Mahanadi to the Godavari, and constitutes the high plateaux of the eastern Ghats in the northern Circars.

### 3.—Burma.

The geological survey of the northern Shan States, which was started last year, was continued during the cold season of 1900 to 1901, and fair progress has been made in the geological mapping of the country between the Mandalay plains and the Kunlon ferry. Mr. LaTouche worked in the western portion of that area, whilst Mr. Datta remained in the district immediately to the east of Mr. LaTouche's sections. The geological results are very interesting, and to some extent modify the views which Messrs. LaTouche and Datta held after the season 1899-1900. Several horizons, the respective ages of which were left doubtful, have furnished fine collections of fossils, which have helped to clear up the geological relations of the different series of strata, all of which have apparently undergone much disturbance. Dr. Noetling was sent to the northern Shan States to inspect work done by Mr. Datta, and has materially helped to unravel the doubtful points in connection with the structure and ages of the various horizons. He has recognised the triassic age of the Gokteik series of beds, regarding which much difference of opinion existed between Messrs. LaTouche and Datta during the season of 1899 to 1900. The former officer described the Kyinsi beds as doubtfully devonian (General Report, 1899-1900, page 77), whilst Mr. Datta claimed for the same horizon as well as

Mr. T. H. D. LATOUCHE,  
" P. N. DATTA.  
Dr. F. NOETLING.

for the Gokteik beds (*ibid*, page 120) an age not older than triassic and probably jurassic.<sup>1</sup>

In a country such as the northern Shan hills, which is not only covered with extensive forests and dense undergrowth, but the surface of the rocks of which is so greatly disintegrated that frequently the actual rock is covered by a soil-cap of some fifty feet in thickness and more, it is extremely difficult to arrive at anything but a mere outline of the geological structure of the area beneath the soil-cap, and therefore the details of the geological sections can never be more than mere guesses, but fortunately most of the beds contain fossils and therefore their ages may be ascertained approximately.

It was not possible to do more than establish a number of series of beds, which so far have eluded close comparisons, owing to the fact that they mostly occur in localities separated from each other by tracts within which none or only very bad exposures have been observed. Mr. Datta, for instance, has been describing quite a considerable number of such local sub-divisions, which can scarcely be compared one with the other, as there is nowhere or at least rarely clear evidence of their respective structural relations. Consequently much that has been assumed is based upon very slender evidence, and will probably have to be revised hereafter.

There are several facts, however, which have been established and the most important amongst them are: First, *Older Crystallines with slates.* that the oldest rocks known in the northern Shan hills consist of coarse-grained biotite garnetiferous gneiss with bands of coarsely crystalline limestone, which latter forms the matrix of the rubies of Mogok. Mr. LaTouche also found tourmaline granite with gabbro intrusive in a mica-schist which follows upon these older rocks. The mica-schist seems to pass upwards into a slaty series, and the latter may be Cambrian according to Mr. LaTouche.

Above follow several distinct systems of sedimentary rocks, most of them fossiliferous. The contact of this complex of beds with the slates and schists below *Sedimentary beds.*

<sup>1</sup> Note by Mr. LaTouche. "A word of explanation seems necessary here. On first discovering these beds at Kyinsi, I discovered them to be jurassic and entered them as such in my field note book. But on my return to head-quarters, I was assured positively by Dr. Noetling that some of the fossils at least were devonian, and I accordingly referred the beds doubtfully to that age in my progress report." T. D. L.

seems invariably to be a faulted one. I think it is evident from the preliminary reports sent in by all three observers that within this large complex of sedimentary beds at least two unconformities may be recognised, and that one of them is a distinct one which may be clearly observed. It occurs above the system of limestones

*Silurian.*

and shales, which all observers, including Dr. Noetling, who had described it first, determine as representing both upper and lower silurian. This system, which can be well divided into several distinct horizons, has already been described by Mr. LaTouche in his progress report, published in the General Report for 1899-1900, but a few additions and corrections have been recorded, which have not materially changed the general sequence of the beds as was described last year. Mr. Datta comprises the whole of the lower silurian under the name of the Tonbo beds, and neglects to further sub-divide this series, although several clearly defined horizons, each well characterised palæontologically, may be distinguished within the lower silurian, as shown by Mr. LaTouche.

Between the silurian system and the beds which come next in order of deposition a distinct unconformity has been observed; the partly denuded silurian strata are unconformably overlaid by a series of beds with badly preserved fossils, which Mr. LaTouche calls the Maymyo beds, and which Mr. Datta sub-divides into lower and upper series (the Maymyo and Wetwin beds). They were formerly considered as upper silurian by Mr. LaTouche and devonian by Mr. Datta, but it seems probable that the upper portion of it at least is younger and may possibly represent the permian system. A recent find by Mr. LaTouche of *Calceola sandalina* in the Maymyo limestone seems to establish the devonian age of at least a portion of this series.

*Mesozoic.*

The contact between the latter and the next younger series of beds is somewhat doubtful, but is possibly unconformable, at least at a few localities. The fact of the matter is, that at several localities, not very close to each other, beds may be observed which are rich in fossils, and which may or may not represent portions of the same series of strata. As yet all the arguments brought forward to prove the superposition in natural sequence of the various sub-divisions of these beds are somewhat apocryphal. Mr. LaTouche comprises the whole of these deposits under the name of the Kyinsi beds, which he formerly

believed to belong to the devonian and which he now refers doubtfully to the jurassic system. Mr. Datta believes that these beds may be divided into three stages, in ascending order, the Kyauk-Kyan, Gokteik and Nawnpeng beds; but until the rich collection of fossils which he has obtained during the last year have been carefully examined, nothing certain can be said about the necessity of subdividing the Kyinsi beds of Mr. LaTouche. Dr. Noetting has recently visited the localities and examined some of their fossils contents, and so far seems convinced that the Gokteik beds belong to the trias; several genera of pelecypods point distinctly to an upper triassic age. The credit of having first recognised the probable triassic age of these beds belongs to Mr. Datta, who has already expressed this view in his progress report for the previous year,<sup>1</sup> in spite of the fact that the peculiar stratigraphical relations of the Gokteik beds point rather to a palæozoic age of the series of strata.

It is to be hoped that further research in these localities will lead to interesting results. The existence of triassic beds in Burma was long ago inferred from some well preserved *Daonella* species in a dark limestone, which have been lying in the Geological Museum for many years past, but with regard to the history of which nothing reliable was known, beyond that they were believed to come from the Karenni country. Mr. Middlemiss was specially deputed, during 1899-1900, to the northern Karenni country in order to re-discover the triassic rocks in which these fossils have been found, but he failed to identify the same. But in view of the fact that triassic beds have now been discovered in the northern Shan States, it seems highly probable that this system will also be found along the southern margin of the Shan "plateau."

According to Mr. Theobald<sup>2</sup> triassic beds, his so-called "Axial group," have been found in the southern spurs of the Arrakan Yoma, and a *Halobia lommeli*, Wiss., was found in beds of this "group," but as this fossil is not to be found in the Geological Museum, and a subsequent survey of some sections of the Arrakan Yoma has not proved the existence of beds older than cretaceous, some doubts have been expressed as to the correct identification of the fossil.

Additional interest is now attached to Mr. Theobald's observations; much of the rocks of the Yoma are developed as flysch, little

<sup>1</sup> General Report for 1899-1900, p. 120.

<sup>2</sup> Mem. Geol. Surv. Ind., Vol. X, p. 36.

if at all differing from the flysch formation of the Himálayas and of Baluchistan, and as in these localities this flysch facies is also characterized by great masses of gabbro. The flysch of Baluchistan and of the Himálayas contains many "klippen" of older rocks, and it would be very interesting to ascertain whether the *Halobia* bearing limestone, which Mr. Theobald has discovered in the Yoma, does not also form a "klippe" in the cretaceous flysch, but being very limited in extent has eluded re-discovery.

During the season 1899-1900 a considerable thickness of shales *Namyao and Thibaw* and coarse brown-red sandstone containing a few *beds.* traces of fossils were found in the northern Shan hills, which Mr. LaTouche terms the Namyao and Mr. Datta the Thibaw beds. The former observer includes this series of beds amongst the palæozoic rocks, whilst Mr. Datta classes them doubtfully with the tertiaries. These rocks have not been met with during this year's progress of surveys, but I wish to draw special attention to the same here, as I believe that their real origin has not been recognised. In the light of what has already been discovered this year, it having been proved that both permian and an older mesozoic series of beds exists in the northern Shan hills, it may well be that these Thibaw beds represent an upper mesozoic,—probably jurassic facies. As a matter of fact these beds seem to resemble the upper Gondwana beds somewhat, and it may be that they really represent them. Special attention will be devoted to the study of these rocks during the next season's work.

#### 4.—Assam.

The area which has been surveyed by Mr. Bose during last season *MR. P. N. BOSE.* comprises the country south-east of Shillong, which may be called the Shillong-Jowai plateau. It rises to heights of about 6,500 feet on the northern side and thence slopes gently southward to elevations ranging from 1,200 to 1,500 feet, and then very steeply to the plains of Sylhet. The line of this steep declivity corresponds closely with the axis of the monoclinal flexure into which the rocks have been thrown at the edge of

the plateau. At the western end of the area, south of Nongjuri and Umia, the axis was found to run W. N. W.—E. S. E., the cretaceous and nummulitic strata south of it dipping S. S. W.; at the eastern end, south of Sandai, its trend changes to E. N. E.—W. S. W., the beds dipping S. S. E.

(a) *The Tertiary System.*

The system was initiated in this area by a period of intermittent subsidence, evidenced by the occurrence in its lower portion of a clear bluish limestone containing eocene marine fossils and intimately associated with bands of thickish, rather coarse sandstone with shale intercalations in which coal is occasionally developed. The limestone is found in greatest force at the foot of the plateau south of the axis of monoclinical flexure at Nongjuri where it forms a jagged sharp-crested ridge. It is, however, rapidly attenuated eastward, dying out altogether just east of the Wamankilla river (Bhobonsora on map). Reappearing south of the village of Utamar, it runs about a mile eastward and then disappears, not being again met with south of the axis of monoclinical flexure for some 20 miles in that direction. This disappearance is apparently due to interrupted development, and also to concealment under alluvium. For, east of the Mangat river at the very edge of the plateau at Sandai and Nongtalang, the limestone is found fairly well developed, forming cliffs, at places 200 feet high, in which occur several very fine and large caves; and west of that river, it is traceable (about four or five miles from the edge of the plateau) nearly all the way from Mauchuni westward to Maokliao through Kundair and Wahmlein (near Sangmang), in fragmentary and much concealed outcrops. This occlusion of the limestone is due to its underground dissolution, the nummulitic ground where its presence or at least former existence is presumable, being much broken and presenting a medley of displaced masses of the associated sandstone.

North of the axis of monoclinical flexure, the best exposure of the limestone I have encountered west of the Mangat is at Wahmlein, where it is about 50 feet thick. Hence it was traced northward, steadily diminishing in thickness, and in small, far-apart, much-obscured patches as far as Nongkredem, 10 miles north of Wahmlein, where in the best exposure it is 14 feet thick. The limestone

is here and at Thanginatte (4 miles south of Nongkredem) overlaid by some 150 to 200 feet of coarseish sandstones with subordinate shales, which are sometimes associated with thin seams of coal. The sandstones are traceable as far as Madli (about a mile north of Nongkredem).

Superposed to all appearance conformably on the nummulitic beds, there occurs south of the axis of monoclinal flexure a series of rather soft, fine-grained sandstones with interbedded shales which form low hills elevated some 100 to 200 feet above the plains of Sylhet.

(b) *The Cretaceous System.*

As developed in the southern portion of the Shillong-Jowai plateau, where the system attains a maximum thickness of over a thousand feet, it is divisible into two well-defined series. Of these, the upper consists of a very fine-grained, compact, grey or dark-grey sandstone weathering yellowish-brown, often more or less calcareous and sometimes earthy, with occasional layers of shale. A tendency towards exfoliation is frequently observable. On the southern border of the plateau the greatest thickness of the series amounts to some 400 feet. It has yielded a fair number of fossils including a nautilus, two or three species of ammonites and some bivalves and gastropods chiefly from the vicinity of Wahmlein and Utamar, west of the Mangat, and of Sandai, east of that river. Traced northward it thins out, ceases to yield determinable fossils (at least none have been obtained as yet), and undergoes lithologic variation indicative of shallow-water conditions.

The lower series is composed mainly of more or less coarse thick-bedded sandstones. On the border of the plateau at Utamar, Saingriang, etc., the sandstones are extremely thick-bedded, brownish, and contain abundant sub-angular specks of flesh-coloured felspar, which give the rock a somewhat tuffaceous aspect. A short distance to the north, however, about Sangmang, Kundair, etc., the rock becomes greyish-white, and the felspar disappears. The sandstones are frequently conglomeratic towards the base, and rarely towards the top as well. The conglomerate is very irregularly developed, thickening and thin-

ning out rapidly, but is never altogether absent at least for any considerable distance.

The maximum thickness of the series at the southern extremity of the area is not less than 700 feet. Fossils are rare; the few that have been found appear to be different from those of the upper series.

At Jowai and its vicinity, there are some coarse sandstones with interbedded shales and conglomerates at their base and they are occasionally carbonaceous. Though they strongly resemble the sandstones which at or near the edge of the plateau rest upon nummulitic limestone and have the appearance of passing into the latter, Mr. Bose prefers to include them with the cretaceous system as Mr. La Touche did when he traversed through Jowai.

Mr. Bose came across sections which show the cretaceous platform on which the nummulitics were laid down to have been at places very uneven, and argues that this may be due to marine denudation alone; in fact, the balance of evidence seems to be in favour of such a supposition. The close parallelism which is observable between the two systems, whether disturbed or not, suggests that they were upheaved together and disturbed synchronously; and their concurrent increase in thickness and exhibition of deep-water characters in the southern direction tend to show that the subsidence which began in the cretaceous period continued with intermissions until the supra-nummulitic deposits were laid down.

*Relation of the cretaceous to the tertiary system.*

The relation to the older rocks is one of well marked unconformity.

### (c) *The Sylhet trap.*

The Sylhet trap underlies the cretaceous rocks in deep valleys in the southern portion of the plateau at Sangmang and Umia. It is absent from the sections in the Mangat and to the east of that river.

### (d) *The sub-metamorphic and metamorphic rocks.*

The Shillong series assumes a highly altered aspect at and south of Lailangkot and about Puriang on the Shillong-Jowai road,

micaceous schist being the predominant rock, and it is noteworthy that in both cases the increased metamorphism accompanies igneous intrusions on an extensive scale.

In the vicinity of Jowai Mr. Bose came upon gneiss intimately associated with well foliated mica-schist. These rocks are well displayed in the valley of the Mangat, west of Jarain and north of Nongpadu. The Jowai area has not yet been examined in detail.

(e) *Intrusive rocks.*

The principal occurrences of granite in the area surveyed are north of Lailangkot, north of Nartiang, and in the southern portion of the valleys of the Mangat and the Rangapani. Everywhere it is typically a coarsely crystalline rock with large well developed flesh-coloured felspar. Its intrusive character is fairly well displayed in the vicinity of Lailangkot where it cuts obliquely across the strike of the Shillong series, and where, besides, included pieces of the Shillong quartzite were occasionally observed in it.

With regard to the age of the granite, all that can be said is that it must have intruded through the Shillong series a long time before the deposition of the cretaceous strata, for these were found to rest upon a much denuded surface of the granite in the Mangat valley about Kapeuter.

Besides granite, a dense, heavy, hard black basic rock which Mr. Medlicott calls Khasia greenstone in the Chera area, is found intrusive in the Shillong series.

## 5.—Sind—a correction.

A short report on the progress of the work carried on by Dr. Noetling in Sind during the year 1899 to 1900 contains so many printer's errors and accidental ambiguities that I find it necessary to

give a corrected version here. The sequence of the beds of the Laki range should be in descending order :—

Strata with Nummulites.	Eocene.	Upper Eocene.	Nari stage	17. Zone of <i>Cerithium</i> , spec. nov.
				16. Zone of <i>Eupatagus rostratus</i> , d'Arch.
				15. Zone of <i>Echinolampas discoideus</i> , Dun.
		Lower Eocene.	Ranikot stage	14. Nodular limestone not subdivided.
				13. Zone of <i>Anomia</i> , spec. nov.
				12. Zone of <i>Cardita</i> , spec. nov.
				11. Zone of <i>Pugnellus</i> , spec. nov.
				10. Zone of <i>Nummulites granulosus</i> , d'Orb.
				9. Alveolina-limestone.
				8. Zone of <i>Macropneustes speciosus</i> , Dun.
Strata without Nummulites.	Upper Cretaceous.	Jhakmari stage		7. Zone of Gen. nov. spec. nov. ( <i>Rostellaria</i> , Blanf.).
				6. Unfossiliferous sandstone.
				5. Zone of <i>Ostrea lingua</i> , Lam. (?).
				4. Basalt.
				3. Zone of <i>Turritella</i> , spec. nov.
				2. Zone of <i>Cardita beaumonti</i> , d'Arch.
				1. Nodular limestone not subdivided.

The sequence of beds is throughout a conformable one, and the boundary between the cretaceous and the tertiary systems was drawn at the base of zone 8, in which the first *Nummulites* appear together with numerous *Macropneustes speciosus*, Dun.

## 6.—Himálayas.

It was originally planned to have an exhaustive study made of the Chitichun area of the Central Himálayas, within which the highly interesting "Klippen" occur, which I described in Records, Vol. XXVI, page 19, but political considerations made a longer residence within that particular area inadvisable and Dr. von Krafft's researches were therefore restricted to the adjoining ground and to the neighbourhood of the Balchdhura pass, north of Milam in Kumaon. Dr. von Krafft also found time to pay a visit to the Shalshal cliff from where he obtained some good fossils. However, before proceeding to the "Klippen" area of the Balchdhura he proceeded to Byans (Kumaon) in order to examine some special localities already known through my own and Mr. F. H. Smith's work. Dr. von Krafft has come to the conclusion that the triassic series of Byans differs somewhat from that of Johar, Painkhanda and Spiti, the series between the lower trias and the *Tropites* horizon, which in Spiti amounts to approximately 2,000 feet, being reduced in Byans to 250 feet of grey limestone. Another difference consists in the occurrence of black shales above the *Tropites* limestone. Large collections were made, chiefly from the *Tropites* limestone, in addition to those already in hand.

The local Government having strictly prohibited Dr. Krafft from crossing the frontier, he received instructions to proceed to the Bambanag cliff and thence to the Laptal area. At the Bambanag cliff and subsequently at the Shalshal cliff, which was visited on the return march in September, detailed researches were made into the muschelkalk, which was found to correspond exactly with that of Spiti. The lower muschelkalk is of much greater thickness than was hitherto believed, including in descending order—

- (3) Beds with *Ceratites subrobustus* and other cephalopoda (see General Report, 1899-1900, page 204), in common with brachiopoda, among which *Spiriferina stracheyi* is prominent.
- (2) A nodular limestone without fossils.
- (1) Thin, earthy limestones with *Rhynchonella griesbachi*, Bitt., etc. It has now been definitely ascertained that *Ceratites subrobustus* does not belong to the lower trias and the

term "*subrobustus beds*" in the sense as applied by Dr. Diener must be discarded, and it appears certain that the lower muschelkalk includes two brachiopod-horizons.

At the Shalshal cliff *Daonella indica* was found in great numbers 25 feet below the "*Traumatocrinus* limestone" and immediately above the beds with *Ptychites rugifer*. This small thickness represents the ladinic stage, hitherto recorded only from Spiti, where it amounts to approximately 300 feet, and is much richer in fossils. The "*Traumatocrinus* limestone" includes *Foannites cymbiformis* as asserted by E. v. Mojsisovics, and thus corresponds to the shales with *Foannites cymbiformis* of Spiti. The specimens of this species recently found at the Shalshal cliff differ from those which v. Mojsisovics had compared with the above-mentioned Alpine species. *Tropites* have not been found either at the Bambanag nor at the Shalshal cliff, but a well preserved specimen of *Griesbachites medleyanus*, a species of the *Tropites* horizon, was obtained from the topmost *Daonella* beds near Martoli.

This species occurs in an "exotic block" north of the Balchdhura pass together with *Tropites*. The site of the *Tropites* horizon is therefore, as supposed by E. v. Mojsisovics, immediately below the "*Hauerites* beds." The "*Hauerites*" and "*Sagenites* beds" are too poor in cephalopoda to be termed cephalopod-horizons, as has been done. Large collections were obtained from the "*Halorites* beds." Above the "*Sagenites* beds" the same quartzite series was found as in Spiti. At the Bambanag cliff it includes *Aulacothyris joharensis* and (?) *Spirigera noetlingi*.

During July and August Dr. v. Krafft examined in detail the area east of Laptal, where in 1892 myself, Diener and Middlemiss had found "exotic blocks" The country is chiefly composed of flysch, consisting of two main divisions, viz., the "Gieumal sandstone" (Stoliczka) and a series of red and black shales and green sandstones, which may be assigned to the lower tertiary system. No Chikkim limestone is developed. The flysch is overlain by huge masses of basic igneous rocks, viz., andesites, in common with volcanic breccias and tuffs, representing flows, not intrusive rocks as was previously assumed. These include innumerable limestone blocks. Most of them are massive, grey and unfossiliferous, many are red and a few of them yielded numerous fossils. The following horizons are repre-

sented among the red limestones: permo-carboniferous (often also white limestone), lower trias (horizon of *Flemingites rohilla*), ladinic or lower carnic stage (*Daonella indica*), *Tropites* limestone and lower lias with *Arietites* and *Phylloceras* (first discovery of lias ammonites in India). The grey limestones may be correlated with the Dachsteinkalk, but may in part be equivalent in age to the red limestones. Green sandstones (Gieumal sandstone?) were also found as "exotic blocks", some of them mixed up with shales (Spiti shales?), also various members of the supposed nummulitic series.

In the neighbourhood of the Balchdhura pass the country is little disturbed, but further south the structure becomes more and more complicated, tight folds and overthrusts being seen. The lavas participate in all the disturbances in the same manner as do the sedimentary beds.

The origin of the exotic blocks must be attributed to violent volcanic outbursts, which have brought the blocks up to the surface after they were torn from a series of beds *in situ*. This series, which in part resembles that of the Hallstatt area, must be supposed to be buried underneath the neighbouring Tibetan plain and where the lavas are known to be widely distributed. The volcanic outbursts no doubt occurred during the older tertiaries and were presumably preceded by a short period of denudation, while they were followed by those disturbances that led to the ultimate upheaval of the Himálayas.

The lower trias and the productus beds of the Himálayas have to a certain extent served in recent times as a key to the correct interpretation of the similar horizons occurring elsewhere in India, notably in the Salt range, where Dr. Noetling was carrying on special researches during the cold weather of 1899 to 1900 which have already been noticed in last year's General Report, page 41. In the "*Neue Jahrbuch für Mineralogie, etc.*," for 1900, pages 139 to 141, he sets forth his views more fully, and they were answered by Professor C. Diener in the "*Centralblatt*" for 1900, pages 1 to 5. The main idea expressed in Dr. Noetling's paper in the "*Neue Jahrbuch*" differs slightly from the notice of his work given in last year's General Report; he held the view that we must include the entire series of ceratite beds of the Salt range with the permian system. The report that he has found true *Otoceras*, probably *O.*

DR. F. NOETLING.

Lower trias of the  
Himálayas and of the  
Salt range.

*woodwardi*, Gries, has since turned out to be incorrect, as already noticed on page 42 of my General Report for the year 1899-1900.

The views which Dr. Noetling expressed in the "Neue Jahrbuch" and in the reports which he has sent in, differed so much from my own and those of previous observers in the Himálayan and Salt range areas, that I determined to depute him to several of the best known localities in the Central Himálayas, in order to study the boundaries between the undoubted permian and the *Otoceras* beds. When I myself worked out the sequence of strata from the lowest silurian to jurassic systems I recognised at once that a considerable thickness of beds occurred between the *productus* beds and the undoubted muschelkalk, the latter of which was already known to occur in India. This intercalated series of beds yielded many fossils, amongst others my new genus *Otoceras*, which is found in hard limestone (bed 2), *i.e.*, in the stratum which rests immediately on the dark *productus* shales, which latter yielded numerous *productus* species and in harder layers many brachiopods of permian type.

After considerable thought I decided to include the whole series from "bed 2" to the lowest beds of the muschelkalk with the lower trias, although the very lowest horizons of this series I looked upon as "*passage beds*" (see Memoirs, XXIII, page 147):—

"I regard them as permian,<sup>1</sup> and the *Otoceras* beds above as a passage series from the permian into the lower trias, with which it is structurally closely connected in the Central Himálayas. The *upper* beds of this division must then be a representative of the lowest trias. The fauna contained in it, though some of the species remind one of similar forms found in the Alpine Buntsandstein (Werfen beds), has, on the whole, rather a permian character than triassic."

Dr. Noetling adopts this view also, but goes further, inasmuch as he draws the actual boundary between the permian and trias systems above the *Otoceras* beds and below certain beds of the series, which contain *Meekoceras* sp.—I prefer to consider them still as true passage beds; of the types contained in them some may be referred to permian forms, but some, especially bivalves, to lower trias (Werfen) beds, but it appears certain that none of the *Productus* species ascend into *Otoceras* yielding strata.

<sup>1</sup> The black shales with *Productus*.

Dr. Noetling has now divided this series of beds, which form an uninterrupted complex of thin limestone and shale layers, into four palæontological zones, and draws the boundary between the permian and trias systems above the lower two horizons, the very beds in fact which I call passage beds in the paragraph quoted from my report on the Central Himálayas.

In the lower beds of limestone and shales with *Otoceras woodwardi* or *Ophiceras tibeticum* he recognises two horizons; these are overlaid by beds with *Meekoceras noetlingi*, Krafft, followed by beds with *Hedenstræmia* spec., which were termed erroneously sub-robustus beds formerly. These two latter horizons Dr. Noetling asserts, form the lower trias in the Himálayas, whilst the zone of *Otoceras woodwardi*, Gries., and *Ophiceras tibeticum*, Gries., would represent the uppermost beds of the permian. This view is strongly supported by the occurrence of *Medlicottia dalailamæ*, Dien., which according to Dr. Noetling is identical with *Medlicottia wynnei*, Waag., a species which hitherto has been found in permian beds only. As the genus *Otoceras* occurs elsewhere in permian beds only, my original view that the *Otoceras* beds are approximately of the same age as the Julfa beds in Armenia is fully corroborated by Dr. Noetling's researches.

## 7.—Baluchistan.

Owing to the severe cold which prevails in winter at the high level of the Koják hills and the upper Zhob valley, it was found more convenient to permit Mr. Vredenburg to commence work in the Chágai and Nushki districts. Observations made during a journey performed in 1898-99 are being published in the Memoirs, Volume XXXI, and a closer examination has now been made of some of the regions therein mentioned, and also of some adjoining districts which could not be visited on that first occasion.

Special attention was paid first of all to the Chapar range, a long line of high-dipping limestones situated some fifteen miles south of Chagai and running in an east-west direction. It was pointed out in the Memoir above mentioned, that the limestone resembles some rocks of upper creta-

Chapar range. Fossils.

aceous age that form, further west, a hill called Malik Gatt. But no fossils could be found in the eastern part of the range, the "Masá-nen Chapar." A fossiliferous band, however, has been discovered in the upper beds of the limestone of the "Kasá-nen Chapar," which is the western extension of that same range. The main fossiliferous band is scarcely more than one foot in thickness, but its outcrop can be followed for a distance of several miles, and a numerous collection of fairly well preserved specimens has been gathered, amongst which the species *Cardita beaumonti* is specially abundant. It characterises the upper cretaceous horizon in Sind and in Baluchistan, and in the present instance it belongs to the variety *baluchistanensis* described by Dr. Noetling. Other genera, some of which are represented by several species, are *Ostrea*, *Leda*, *Modiola*, *Cardium*, *Corbula*, *Natica*, *Turbo*, *Pugnellus*, *Rostellaria*, *Cerithium*, *Turritella*. At a slightly higher horizon are found some dwarfed specimens of *Cardita*, *Nerita*, *Natica* and some *Cerithidæ*. The strata overlying these fossiliferous beds are shales and sandstones with vegetable impressions which have an estuarine appearance, and recall some of the Ranikot beds in Sind met with at a similar horizon. The shales are sometimes carbonaceous. Only a small thickness of these beds is exposed: owing to the northerly dip, the section generally ascends in a northerly direction, with many repetitions due to folds and faults, and it is soon interrupted by a great intrusion of quartz-diorite. The main limestone mass, together with the more or less shaly partings in its upper and lower portion, has a thickness of about 300 feet. The compact portion of the limestone consists principally of reef-building corals which are only seen on the weathered surface. It rests upon a considerable thickness of green shales and sandstones, similar in appearance to those that constitute the Kojak hills, and, lithologically indistinguishable from other masses of shales which outcrop in other parts of this district and which the presence of *nummulites* shows to be tertiary. In the case of the Chapar hills, notwithstanding a considerable amount of disturbance, the section is sufficiently clear and continuous to leave no doubt as to the inferior position of the shales, relatively to the upper cretaceous limestone. It is therefore evident that these green shales occur both amongst the upper cretaceous and the eocene strata, and, as the rocks are often unfossiliferous and the structure usually highly disturbed, there must

remain many instances where it is difficult to decide to what period they belong. It is interesting to note that some conglomerates interbedded with the shales of the Chapar, contain rolled pebbles of hippuritic limestone, showing that the latter rock was exposed to denudation before the close of the cretaceous period.

The structure of the Chapar hills is a complicated one, with numerous folds and overthrusts in two directions at right angles to one another, but, as made evident by the fairly good preservation of the fossils, the disturbance is not so extreme in its character as in the Kharán hills to be mentioned hereafter. Slaty cleavage, almost universally present in the Kharán hills, does not affect the shales of the Chapar range.

The Kharán mountains form the southern limit of the desert which constitutes the Nushki-Chágai district.

*Kharán hills.*

The northern watershed belongs to that area while the part south of the watershed is included within the territories ruled by Sirdár Sir Naoraz Khán of Kharán. Several portions of this range were visited during the preliminary examination of the district, and are described in the Memoir above-mentioned, attention being drawn to the very irregular structure of these mountains. During the present season, the survey was carried further west than previously. Between the longitudes  $64^{\circ} 15'$  and  $65^{\circ} 15'E$ , the mountain mass may be divided into three zones: a northern zone consisting mainly of intrusive rocks; a middle zone, principally shales converted into slates; and a southern zone consisting of tall limestone ridges. To the northern zone belong the great intrusions of the Ras Koh, details of which have already been published. Further west, another intrusive mass has been discovered south and south-west of Dálbandin. Like the Ras Koh, it forms an oval outcrop along the northern edge of the mountainous region. The topographical maps available, although very accurate, are on too small a scale to show the intricate detail of these igneous rocks. Nevertheless, these rocks have been studied very carefully, with a view to comparing them with some igneous intrusions yet unsurveyed in the Kojak range, the topography of which has been worked out in much greater detail. The rocks forming the intrusive mass south to Dálbandin belong to many different varieties. The centre of the mass contains the coarsest-grained rocks, and these differ from the surrounding ones not only by their texture, but also by

their composition, which is more acid. They are pale-coloured syenites, while the surrounding rocks are diorites and diorite-porphyrries. The syenite sends veins into the basic rocks and includes fragments of them, showing that it was intruded last. The numerous varieties of diorite do not form concentric zones round this syenitic nucleus, but are dovetailed in a very irregular manner. In the southern portion of the outcrop, the texture remains a fine-grained granitic one even quite close to the edge of the outcrop, while along the northern edge there are hills entirely made up of porphyry. The sedimentary rocks are considerably altered at their junction with the intrusion, and great lenticular masses of strata are often included in the very midst of the plutonic mass which, when seen from a distance, assumes quite a stratified appearance. It is probable that some of the slates have been actually fused, or at least dissolved, and that the admixture of their material with that of the igneous intrusion may account partly for the very irregular composition of the latter. As in the Ras Koh, the rocks of the igneous mass are generally remarkable for the absence of quartz and the presence of a large proportion of sphene.

The southern zone of the mountain mass, that bordering the northern edge of the Kharán desert, consists of numerous tall ridges of limestone. All these ridges are repetitions of one band of nummulitic limestone about 350 feet thick. At Jálawar there are no less than seven of these parallel ridges, sometimes with a distinct synclinal or anticlinal structure, more frequently very irregularly faulted and fractured. The Kharán desert is limited to the north by an almost vertical wall formed sometimes by the upper, sometimes by the lower surface of the tilted limestone. Only the most northern of these limestone ridges was seen during the preliminary examination of this country. Their eastern limit has not been observed. The outcrop extends from at least the neighbourhood of Kharán in an easterly direction up to Long.  $64^{\circ} 25'E$ , west of which they sink beneath the alluvium of the desert. The strike of these ridges is very regular and runs a few degrees north of east, while in the middle zone of the mountain mass, the zone extending between the limestone ridges to the south and igneous intrusions to the north, the ridges strike north-east. It seems that during the process of folding of the strata, considerable portions of the rocks have been displaced in such a manner as to glide past one another horizontally, in addition to the more or less vertical displacements which have resulted in

ordinary flexures and overthrusts. Slaty cleavage is the general rule, and it is to be noticed that the cleavage planes strike north-east like the ranges of the middle zone, and that in the southern zone, where the shales associated with the nummulitic limestone are also slaty, the strike of the cleavage does not change, and hence it crosses the strike of the stratification at an angle of about  $30^{\circ}$ .

As already stated in the Memoir now in the press, the greenish-grey slates of this range, with occasional bands of sandstone and limestone, are all tertiary as is shown by the *nummulites* which their limestone bands contain. But, beyond showing that they are eocene, the circumstances observed do not allow their age to be determined with any closer approximation. Except *nummulites* and *alveolinæ*, no other fossils can be recognised, and although there is no doubt as to their generic attribution, they are so badly preserved that specific determinations are scarcely reliable. Occasionally the species *N. granulosa* can be recognised, but it is one that has a wide geological range. It is not even possible to tell for certain whether these strata are generally newer or older than the limestone of the southern ridges, for the same monotonous succession of green shales is observed both above and below that limestone. In the western portion of the range which has been latterly examined, there is a series of bright-coloured shales interstratified with beds containing a large proportion of volcanic material. The disturbed structure and the complete absence of fossils do not allow the age of these beds to be fixed, though it is probable that they are either upper cretaceous or lower tertiary.

It should be noted that the situation of the intrusive masses does not stand in any relation to the occurrence or otherwise of slaty cleavage, for considerable intrusions exist both in the neighbourhood of the Chapar ranges where the shales are not cleaved, and in the Kharán mountains, which consist almost entirely of well-cleaved slates. Indeed, the cleavage becomes less distinct in the immediate neighbourhood of the plutonic rocks owing to the effects of contact alteration.

Special attention was paid to the possible existence of useful minerals, as great efforts are being made at present to develop this region. Nearly all the igneous rocks are cupriferous, especially the more basic varieties, and it is possible therefore that there may exist local accumulations

of copper ore in paying quantity, but none have been met with so far. Signs of the existence of petroleum were observed in the nummulitic limestone and shales along the southern border of the Kharán hills.

CALCUTTA, }  
The 31st March 1901. }

C. L. GRIESBACH, *Director,*  
*Geological Survey of India.*



*Part 3.*—Note on the progress of the gold industry in Wynaad, Nilgiri district. Notes on the representatives of the Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.

*Part 4.*—On the geographical distribution of fossil organisms in India. Submerged forest on Bombay Island.

#### VOL. XII, 1879.

*Part 1.*—Annual report for 1878. Geology of Kashmir (third notice). Further notices of Siwalik mammalia. Notes on some Siwalik birds. Notes of a tour through Hangrang and Spiti. On a recent mud eruption in Ramri Island (Arakan). On Braunite, with Rhodonite, from near Nagpur, Central Provinces. Palæontological notes from the Satpura coal-basin. Statistics of coal importations into India.

*Part 2.*—On the Mohpani coal-field. On Pyrolusite with Psilomelane occurring at Gosalpur, Jabalpur district. A geological reconnaissance from the Indus at Kushalgarh to the Kurram at Thal on the Afghan frontier. Further notes on the geology of the Upper Punjab.

*Part 3.*—On the geological features of the northern part of Madura district, the Pudukota State, and the southern parts of the Tanjore and Trichinopoly districts included within the limits of sheet 80 of the Indian Atlas. Rough notes on the cretaceous fossils from Trichinopoly district, collected in 1877-78. Notes on the genus *Sphenophyllum* and other Equisetaceæ, with reference to the Indian form *Trizygia Speciosa*, Royle (*Sphenophyllum Trizygia*, Ung.). On Mysorin and Atacamite from the Nellore district. On corundum from the Khasi Hills. On the Joga neighbourhood and old mines on the Nerbudda.

*Part 4.*—On the 'Attock Slates' and their probable geological position. On a marginal bone of an undescribed tortoise, from the Upper Siwaliks, near Nila, in the Potwar, Punjab. Sketch of the geology of North Arcot district. On the continuation of the road section from Murree to Abbottabad.

#### VOL. XIII, 1880.

*Part 1.*—Annual report for 1879. Additional notes on the geology of the Upper Godavari basin in the neighbourhood of Sironcha. Geology of Ladak and neighbouring districts, being fourth notice of geology of Kashmir and neighbouring territories. Teeth of fossil fishes from Ramri Island and the Punjab. Note on the fossil genera *Nöggerathia*, Stbg., *Nöggerathiopsis*, Fstm., and *Rhiptozamites*, Schmalh., in palæozoic and secondary rocks of Europe, Asia, and Australia. Notes on fossil plants from Kattywar, Shekh Budin, and Sirgulah. On volcanic foci of eruption in the Konkan.

*Part 2.*—Geological notes. Palæontological notes on the lower trias of the Himalayas. On the artesian wells at Pondicherry, and the possibility of finding such sources of water-supply at Madras.

*Part 3.*—The Kumaun lakes. On the discovery of a celt of palæolithic type in the Punjab. Palæontological notes from the Karharbari and South Rewah coal-fields. Further notes on the correlation of the Gondwana flora with other floras. Additional note on the artesian wells at Pondicherry. Salt in Rajputana. Record of gas and mud eruptions on the Arakan coast on 12th March 1879 and in June 1843.

*Part 4.*—On some pleistocene deposits of the Northern Punjab, and the evidence they afford of an extreme climate during a portion of that period. Useful minerals of the Arvali region. Further notes on the correlation of the Gondwana flora with that of the Australian coal-bearing system. Note on reh or alkali soils and saline well waters. The reh soils of Upper India. Note on the Naini Tal landslip, 18th September 1880.

#### VOL. XIV, 1881.

*Part 1.*—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts, being fifth notice of the geology of Kashmir and neighbouring territories. Note on some Siwalik carnivora. The Siwalik group of the Sub-Himalayan region. On the South Rewah Gondwana basin. On the ferruginous beds associated with the basaltic rocks of north-eastern Ulster, in relation to Indian laterite. On some Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on the lower trias of the Himalayas.' On some mammalian fossils from Perim Island, in the collection of the Bombay Branch of the Royal Asiatic Society.

- Part 2.**—The Nahan-Siwalik unconformity in the North-western Himalaya. On some Gondwana vertebrates. On the ossiferous beds of Hundes in Tibet. Notes on mining records, and the mining record office of Great Britain; and the Coal and Metalliferous Mines Acts of 1872 (England). On cobaltite and danaites from the Khetri mines, Rajputana; with some remarks on Jaipurite (Syepoorite). On the occurrence of zinc ore (Smithsonite and Blende) with barytes, in the Karnul district, Madras. Notice of a mud eruption in the island of Cheduba.
- Part 3.**—Artesian borings in India. On oligoclase granite at Wangtu on the Sutlej, North-west Himalayas. On a fish-palate from the Siwaliks. Palæontological notes from the Hazaribagh and Lohardagga districts. Undescribed fossil carnivora from the Siwalik hills in the collection of the British Museum.
- Part 4.**—Remarks on the unification of geological nomenclature and cartography. On the geology of the Arvali region, central and eastern. On a specimen of native antimony obtained at Pulo Obin, near Singapore. On Turgite from the neighbourhood of Juggiapett, Kistnah district, and on zinc carbonate from Karnul, Madras. Note on the section from Dalhousie to Pangi *via* the Sach Pass. On the South Rewah Gondwana basin. Submerged forest on Bombay Island.

VOL. XV, 1882.

- Part 1.**—Annual report for 1881. Geology of North-west Kashmir and Khagan (being sixth notice of geology of Kashmir and neighbouring territories). On some Gondwana labyrinthodonts. On some Siwalik and Jamna mammals. The geology of Dalhousie, North-west Himalaya. On remains of palm leaves from the (tertiary) Murree and Kasauli beds in India. On Iridosmine from the Noa-Dibing river, Upper Assam, and on platinum from Chutia Nagpur. On (1) a copper mine lately opened near Yongri hill, in the Darjiling district; (2) arsenical pyrites in the same neighbourhood; (3) kaolin at Darjiling (being 3rd appendix to a report on the geology and mineral resources of the Darjiling district and the Western Duars). Analyses of coal and fire-clay from the Makum coal-field, Upper Assam. Experiments on the coal of Pind Dadun Khan, Salt-range, with reference to the production of gas, made April 29th, 1881. Report on the proceedings and result of the International Geological Congress of Bologna.
- Part 2.**—General sketch of the geology of the Travancore State. The Warkilli beds and reported associated deposits at Quilon, in Travancore. Note on some Siwalik and Narbada fossils. On the coal-bearing rocks of the valleys of the Upper Rer and the Mand rivers in Western Chutia Nagpur. On the Pench river coal-field in Chhindwara district, Central Provinces. On borings for coal at Engsein, British Burma. On sapphires recently discovered in the North-west Himalaya. Notice of a recent eruption from one of the mud volcanoes in Cheduba.
- Part 3.**—Note on the coal of Mach (Much) in the Bolan Pass, and of Sharag or Sharigh on the Harnai route between Sibi and Quetta. New faces observed on crystals of stilbite from the Western Ghâts, Bombay. On the traps of Darang and Mandi in the North-western Himalayas. Further note on the connexion between the Hazara and the Kashmir series. On the Umaria coal-field (South Rewah Gondwana basin). The Darangiri coal-field, Garo Hills, Assam. On the outcrops of coal in the Myanong division of the Henzada district.
- Part 4.**—On a traverse across some gold-fields of Mysore. Record of borings for coal at Beddadanol, Godavari district, in 1874. Note on the supposed occurrence of coal on the Kistna.

VOL. XVI, 1883.

- Part 1.**—Annual report for 1882. On the genus *Richthofenia*, Kays (*Anomia Lawrenceana*, Koninck). On the geology of South Travancore. On the geology of Chamba. On the basalts of Bombay.
- Part 2.**—Synopsis of the fossil vertebrata of India. On the Bijori Labyrinthodont. On a skull of *Hippotherium antilopinum*. On the iron ores, and subsidiary materials for the manufacture of iron, in the north-eastern part of the Jabalpur district. On laterite and other manganese ore occurring at Gosulpore, Jabalpur district. Further notes on the Umaria coal-field.
- Part 3.**—On the microscopic structure of some Dalhousie rocks. On the lavas of Aden. On the probable occurrence of Siwalik strata in China and Japan. On the occurrence of *Mastodon angustidens* in India. On a traverse between Almora and Mussooree made in October 1882. On the cretaceous coal-measures at Borsora, in the Khasia Hills, near Laour, in Sylhet.

*Part 4.*—Palæontological notes from the Daltonganj and Hutar coal-fields in Chota Nagpur. On the altered basalts of the Dalhousie region in the North-western Himalayas. On the microscopic structure of some Sub-Himalayan rocks of tertiary age. On the geology of Jaunsar and the Lower Himalayas. On a traverse through the Eastern Khasia, Jaintia, and North Cachar Hills. On native lead from Maulmain and chromite from the Andaman Islands. Notice of a fiery eruption from one of the mud volcanoes of Cheduba Island, Arakan. Notice.—Irrigation from wells in the North-Western Provinces and Oudh.

#### VOL. XVII, 1884.

*Part 1.*—Annual report for 1883. Considerations on the smooth-water anchorages or mud banks of Narrakal and Alleppy on the Travancore coast. Rough notes on Billa Surgam and other caves in the Kurnool district. On the geology of the Chuari and Sihunta parganas of Chamba. On the occurrence of the genus *Lyttonia*, Waagen, in the Kuling series of Kashmir.

*Part 2.*—Notes on the earthquake of 31st December 1881. On the microscopic structure of some Himalayan granites and gneissose granites. Report on the Choi coal exploration. On the re-discovery of certain localities for fossils in the Siwalik beds. On some of the mineral resources of the Andaman Islands in the neighbourhood of Port Blair. The intertrappean beds in the Deccan and the Laramie group in western North America.

*Part 3.*—On the microscopic structure of some Arvali rocks. Section along the Indus from the Peshawar Valley to the Salt-range. On the selection of sites for borings in the Raigarh-Hingir coal-field (first notice). Note on lignite near Raipore, Central Provinces. The Turquoise mines of Nishâpûr, Khorassan. Notice of a further fiery eruption from the Minbyin mud volcano of Cheduba Island, Arakan. Report on the Langrin coal-field, South-west Khasia Hills. Additional notes on the Umaria coal-field.

*Part 4.*—On the Geology of part of the Gangasulan pargana of British Garhwal. On fragments of slates and schists imbedded in the gneissose granite and granite of the North-west Himalayas. On the geology of the Takht-i-Suleiman. On the smooth-water anchorages of the Travancore coast. On auriferous sands of the Subansiri river, Pondicherry lignite, and Phosphatic rocks at Musuri. Work at the Billa Surgam caves.

#### VOL. XVIII, 1885.

*Part 1.*—Annual report for 1884. On the country between the Singareni coal-field and the Kistna river. Geological sketch of the country between the Singareni coal-field and Hyderabad. On coal and limestone in the Doigrung river, near Golaghat, Assam. Homotaxis, as illustrated from Indian formations. Afghan field-notes.

*Part 2.*—A fossiliferous series in the Lower Himalaya, Garhwal. On the probable age of the Mandhali series in the Lower Himalaya. On a second species of Siwalik camel (*Camelus Antiquus*, nobis ex Fale. and Caut. MS.). On the Geology of Chamba. On the probability of obtaining water by means of artesian wells in the plains of Upper India. Further considerations upon artesian sources in the plains of Upper India. On the geology of the Aka Hills. On the alleged tendency of the Arakan mud volcanoes to burst into eruption most frequently during the rains. Analyses of phosphatic nodules and rock from Mussooree.

*Part 3.*—On the Geology of the Andaman Islands. On a third species of *Merycopotamus*. Some observations on percolation as affected by current. Notice of the Pirthalla and Chandpur meteorites. Report on the oil-wells and coal in the Thayetmyo district, British Burma. On some antimony deposits in the Maulmain district. On the Kashmir earthquake of 30th May 1885. On the Bengal earthquake of 14th July 1885.

*Part 4.*—Geological work in the Chhattisgarh division of the Central Provinces. On the Bengal earthquake of July 14th, 1885. On the Kashmir earthquake of 30th May 1885. On the results of Mr. H. B. Foote's further excavations in the Billa Surgam caves. On the mineral hitherto known as Nepaulite. Notice of the Sabetmahet meteorite.

#### VOL. XIX, 1886.

*Part 1.*—Annual report for 1885. On the International Geological Congress of Berlin. On some Palæozoic Fossils recently collected by Dr. H. Warth, in the Olive group of the Salt-range. On the correlation of the Indian and Australian coal-bearing beds. Afghan and Persian Field notes. On the section from Simla to Wangtu, and on the petrological character of the Amphibolites and Quartz-Diorites of the Sutlej valley.

- Part 2.*—On the Geology of parts of Bellary and Anantapur districts. Geology of the Upper Dehing basin in the Singpho Hills. On the microscopic characters of some eruptive rocks from the Central Himalayas. Preliminary note on the Mammalia of the Karnul Caves. Memorandum on the prospects of finding coal in Western Rajputana. Note on the Olive Group of the Salt-range. On the discussion regarding the boulder-beds of the Salt-range. On the Gondwana Homotaxis.
- Part 3.*—Geological sketch of the Vizagapatam district, Madras. Preliminary note on the geology of Northern Jesalmer. On the microscopic structure of some specimens of the Malani rocks of the Arvali region. On the Malanjkhadi copper-ore in the Balaghat district, C. P.
- Part 4.*—On the occurrence of petroleum in India. On the petroleum exploration at Khátan. Boring exploration in the Chhattisgarh coal-fields. Field-notes from Afghanistan: No. 3, Turkistan. Notice of a fiery eruption from one of the mud volcanoes of Cheduba Island, Arakan. Notice of the Nammianthal aerolite. Analysis of gold dust from the Meza valley, Upper Burma.

Vol. XX, 1887.

- Part 1.*—Annual report for 1886. Field-notes from Afghanistan: No. 4, from Turkistan to India. Physical geology of West British Garhwal; with notes on a route traverse through Jaunsar-Bawar and Tiri-Garhwal. On the geology of the Garo Hills. On some Indian image-stones. On soundings recently taken off Barren Island and Narcondam. On a character of the Talchir boulder-beds. Analysis of Phosphatic Nodules from the Salt-range, Punjab.
- Part 2.*—The fossil vertebrata of India. On the Echinoidea of the cretaceous series of the Lower Narbada Valley, with remarks upon their geological age. Field-notes: No. 5—to accompany a geological sketch map of Afghanistan and North-eastern Khorassan. On the microscopic structure of some specimens of the Rajmahal and Deccan traps. On the Dolerite of the Chor. On the identity of the Olive series in the east with the speckled sandstone in the west of the Salt-range in the Punjab.
- Part 3.*—The retirement of Mr. Medlicott. Notice of J. B. Mushketoff's Geology of Russian Turkistan. Crystalline and metamorphic rocks of the Lower Himalaya, Garhwal, and Kumaun, Section I. Preliminary sketch of the geology of Simla and Jutogh. Note on the 'Lalitpur' meteorite.
- Part 4.*—Note on some points in Himalayan geology. Crystalline and metamorphic rocks of the Lower Himalaya, Garhwal, and Kumaun, Section II. The iron industry of the western portion of the district of Raipur. Notes on Upper Burma. Boring exploration in the Chhattisgarh coal-fields. (Second notice.) Some remarks on Pressure Metamorphism, with reference to the foliation of the Himalayan Gneissose-Granite. A list and index of papers on Himalayan Geology and Microscopic Petrology, published in the preceding volumes of the Records of the Geological Survey of India.

Vol. XXI, 1888.

- Part 1.*—Annual report for 1887. Crystalline and metamorphic rocks of the Lower Himalaya, Garhwal, and Kumaun, Section III. The Birds'-nest or Elephant Island, Mergui Archipelago. Memorandum on the results of an exploration of Jessalmer, with a view to the discovery of coal. A faceted pebble from the boulder bed ('speckled sandstone') of Mount Chel in the Salt-range in the Punjab. Examination of nodular stones obtained by trawling off Colombo.
- Part 2.*—Award of the Wollaston Gold Medal, Geological Society of London, 1888. The Dharwar System, the chief auriferous rock series in South India. On the Igneous rocks of the districts of Raipur and Balaghat, Central Provinces. On the Sangar Marg and Mehowgale coal-fields, Kashmir.
- Part 3.*—The Manganese Iron and Manganese Ores of Jabalpur. 'The Carboniferous Glacial Period.' The sequence and correlation of the pre-tertiary sedimentary formations of the Simla region of the Lower Himalayas.
- Part 4.*—On Indian fossil vertebrates. On the geology of the North-west Himalayas. On blown-sand rock sculpture. Re-discovery of Nummulites in Zanskar. On some mica-traps from Barakar and Raniganj.

Vol. XXII, 1889.

- Part 1.*—Annual report for 1888. The Dharwar System, the chief auriferous rock-series in South India. (Second notice.) On the Wajra Karur diamonds, and on M. Chaper's alleged discovery of diamonds in pegmatite near that place. On the generic position of the so-called *Plesiosaurus Indicus*. On flexible sandstone or Itacolumite, with special reference to its nature and mode of occurrence in India, and the cause of its flexibility. On Siwalik and Narbada Chelonia.
- Part 2.*—Note on Indian Steatite. Distorted pebbles in the Siwalik conglomerate. 'The Carboniferous Glacial Period.' Notes on Dr. W. Waagen's 'Carboniferous Glacial Period.' On the oil-fields of Twingoung and Beme, Burma. The gypsum of the Nehal Nadi, Kumaun. On some of the materials for pottery obtainable in the neighbourhood of Jabalpur and of Umaria.
- Part 3.*—Abstract report on the coal outcrops in the Sharigh Valley, Baluchistan. On the discovery of Trilobites by Dr. H. Warth in the Neobolus beds of the Salt-range. Geological notes. On the Cherra Poonjee coal-field, in the Khasia Hills. On a Cobaltiferous Matt from Nepál. The President of the Geological Society of London on the International Geological Congress of 1888. Tin-mining in Mergui district.
- Part 4.*—On the land-tortoises of the Siwaliks. On the pelvis of a ruminant from the Siwaliks. Recent assays from the Sambhar Salt-Lake in Rajputana. The Manganiferous Iron and Manganese Ores of Jabalpur. On some Palagonite-bearing raps of the Rájmahál hills and Deccan. On tin-smelting in the Malay Peninsula. Provisional index of the local distribution of important minerals, miscellaneous minerals, gemstones, and quarry stones in the Indian Empire. Part 1.

Vol. XXIII, 1890.

- Part 1.*—Annual report for 1889. On the Lakadong coal-fields, Jaintia Hills. On the Pectoral and pelvic girdles and skull of the Indian Dicynodonts. On certain vertebrate remains from the Nagpur district (with description of a fish-skull). Crystalline and metamorphic rocks of the Lower Himalayas, Garhwál and Kumaun, Section IV. On the bivalves of the Olive-group, Salt-range. On the mud-banks of the Travancore coast.
- Part 2.*—On the most favourable sites for Petroleum explorations in the Harnai district, Baluchistan. The Sapphire Mines of Kashmir. The supposed Matrix of the Diamond at Wajra Karur, Madras. The Sonapet Gold-field. Field Notes from the Shan Hills (Upper Burma). A description of some new species of Syringosphæridæ, with remarks upon their structures, &c.
- Part 3.*—On the Geology and Economic Resources of the Country adjoining the Sind-Pishin Railway between Sharigh and Spintangi, and of the country between it and Khattan (with a map). Report of a Journey through India in the winter of 1888-89, by Dr. Johannes Walther, translated from the German, by R. Bruce Foote. On the Coal-fields of Lairungao, Maosandram, and Mao-be-lar-kar, in the Khasi Hills (with 3 plans). Further Note on Indian Steatite. Provisional Index of the Local Distribution of Important Minerals, Miscellaneous Minerals, Gem Stones, and Quarry Stones in the Indian Empire (continued from p. 286, Vol. XXI).
- Part 4.*—Geological sketch of Naini Tal; with some remarks on the natural conditions governing mountain slopes (with a map and plate). Notes on some Fossil Indian Bird Bones. The Darjiling Coal between the Lisu and the Ramthi rivers, explored during season 1890-91 (with a map). The Basic Eruptive Rocks of the Kadaph Area. The Deep Boring at Lucknow. Preliminary Note on the Coal Seam of the Dore Ravine, Hazara (with two plates).

Vol. XXIV, 1891.

- Part 1.*—Annual report for 1890. On the Geology of the Salt-range of the Punjab, with a re-considered theory of the Origin and Age of the Salt Marl (with five plates). On Veins of Graphite in decomposed Gneiss (Laterite) in Ceylon. Extracts from the Journal of a trip to the Glaciers of the Kabru, Pandim, &c. The Salts of the Sambhar Lake in Rajputana, and of the Saline efflorescence called 'Reh' from Aligarh in the North-Western Provinces. Analysis of Dolomite from the Salt-range, Punjab.
- Part 2.*—Preliminary Report on the Oil locality near Moghal Kot, in the Sheráni country, Suleiman Hills. On Mineral Oil from the Suleiman Hills. Note on the Geology of the

Lushai Hills. Report on the Coal-fields in the Northern Shan States. Note on the reported Namsèka Ruby-mine in the Mainglôn State. Note on the Tourmaline (Schorle) Mines in the Mainglôn State. Note on a Salt-spring near Bawgyo, Thibaw State.

*Part 3.*—Boring Exploration in the Daltongunj Coal-field, Palamow (with a map). *Death of DR. P. MARTIN DUNCAN.* Contributions to the study of the Pyroxenic varieties of Gneiss and of the Scapolite-bearing Rocks.

*Part 4.*—On a Collection of Mammalian Bones from Mongolia. Further note on the Darjiling Coal Exploration. Notes on the Geology and Mineral Resources of Sikkim (with a map). Chemical and Physical notes on Rocks from the Salt-range, Punjab (with two plates).

#### VOL. XXV, 1892.

*Part 1.*—Annual report for 1891. Report on the Geology of Thal Chotiáli and part of the Mari country (with a map and 5 plates). Petrological Notes on the Boulder-bed of the Salt-range, Punjab, Subrecent and Recent Deposits of the valley plains of Quetta, Pishin and the Dasht-i-Bedaolat; with appendices on the Chamans of Quetta; and the Artesian water-supply of Quetta and Pishin (with one plate).

*Part 2.*—Geology of the Saféd Kóh (with 2 plates of sections). Report on a Survey of the Jherria Coal field (with a map and 3 section plates) (out of print.)

*Part 3.*—Note on the Locality of Indian Tscheffkinite. Geological Sketch of the country north of Bhamo. Preliminary Report on the economic resources of the Amber and Jade mines area in Upper Burma. Preliminary Report on the Iron-Ores and Iron-Industries of the Salem District. On the Occurrence of Riebeckite in India. Coal on the Great Tenasserim River, Mergui District, Lower Burma.

*Part 4.*—Report on the Oil Springs at Moghal Kot in the Shirani Hills (with 2 plates). Second Note on Mineral Oil from the Suleiman Hills. On a New Fossil, Amber-like Resin occurring in Burma. Preliminary notice on the Triassic Deposits of the Salt-range.

#### VOL. XXVI, 1893.

*Part 1.*—Annual report for 1892. Notes on the Central Himalayas (with map and plate). Note on the occurrence of Jadeite in Upper Burma (with a map). On the occurrence of Burmite, a new Fossil Resin from Upper Burma. Report on the Prospecting Operations, Mergui District, 1891-92.

*Part 2.*—Notes on the earthquake in Baluchistán on the 20th December 1892 (with 2 plates). Further Note on Burmite, a new amber-like fossil resin from Upper Burma. Note on the Alluvial deposits and Subterranean water-supply of Rangoon (with a map).

*Part 3.*—On the Geology of the Sherani Hills (with maps and plates). On Carboniferous Fossils from Tenasserim (with 1 plate). On a deep Boring at Chandernagore. Note on Granite in the districts of Tavoy and Mergui (with a plate).

*Part 4.*—On the Geology of the country between the Chappar Rift and Harnai in Baluchistán (with map and 3 plates). Notes on the Geology of a part of the Tenasserim Valley with special reference to the Tendau-Kamapying Coal-field (with two maps). On a Magnetite from the Madras Presidency containing Manganese and Alumina. On Hislopilite (Haughton) (with a plate).

#### VOL. XXVII, 1894.

*Part 1.*—Annual report for 1893. Report on the Bhaganwala Coal-field, Salt-range, Punjab (with map and 2 plates).

*Part 2.*—Note on the Chemical qualities of petroleum from Burma. Note on the Singareni Coal-field, Hyderabad (Deccan) (with map and 3 plates of sections). Report on the Gohna Landslip, Garhwal (with 5 plates and 2 maps).

*Part 3.*—On the Cambrian Formation of the Eastern Salt-range (with a plate). The Giridih (Karharbari) Coal-field, with notes on the labour and methods of working (with 2 maps and 8 plates of sections). On the Occurrence of Chipped (P) Flints in the Upper Miocene of Burma (with a plate). Note on the Occurrence of Velates Schmideliana, Chemn., and Provelates grandis, Sow. sp., in the Tertiary Formation of India and Burma (with 2 plates).

*Part 4.*—*Note on the Geology of Wuntho in Upper Burma (with a map). Preliminary notice on the Echinoids from the Upper Cretaceous System of Baluchistan. On Highly Phosphatic Mica-Peridotites intrusive in the Lower Gondwana Rocks of Bengal. On 2 Mica-Hypersthene-Hornblende-Peridotite in Bengal.*

VOL. XXVIII, 1895.

*Part 1.*—*Annual report for 1894. Cretaceous Formation of Pondicherry. Some early allusions to Barren Island; with a few remarks thereon. Bibliography of Barren Island and Narcondam, from 1884 to 1894; with some remarks.*

*Part 2.*—*On the importance of Cretaceous Rocks of Southern India in estimating the geographical conditions during later cretaceous times. Report on the Experimental Boring for Petroleum at Sukkur, from October 1893 to March 1895. The development and Sub-division of the Tertiary system in Burma.*

*Part 3.*—*On the Jadeite and other rocks, from Tammaw in Upper Burma. On the Geology of the Tochi Valley. On the existence of Lower Gondwanas in Argentina.*

*Part 4.*—*On the Igneous Rocks of the Giridih (Kurhurbaree) Coal-field and their Contact Effects. On some outliers of the Vindhyan system south of the Sone and their relation to the so-called Lower Vindhyan. Notes on a portion of the Lower Vindhyan area of the Sone Valley. Note on DR. FRITZ NORTLING'S paper on the Tertiary system in Burma, in the Records of the Geological Survey of India for 1895, Part 2.*

VOL. XXIX, 1896.

*Part 1.*—*Annual report for 1895. On the Acicular inclusions in Indian Garnets. On the Origin and Growth of Garnets and of their Micropegmatitic intergrowths in Pyroxenic rocks (with 1 plate).*

*Part 2.*—*Notes on the Ultra-basic rocks and derived minerals of the Chalk (Magnesite) hills, and other localities near Salem, Madras (with 2—6 plates). Preliminary notes on some Corundum localities in the Salem and Coimbatore districts, Madras (with 7—9 plates). On the occurrence of Corundum and Kyanite in the Manbhum district, Bengal. On the papers by DR. KOSSMAT and DR. KURTZ, and on the ancient Geography of "Gondwana-land." Note from the Geological Survey of India.*

*Part 3.*—*On some Igneous Rocks from the Tochi Valley. Notes from the Geological Survey of India.*

*Part 4.*—*Report on the Steatite mines, Minbu District, Burma. Further notes on the Lower Vindhyan (Sub-Kaimur) area of the Sone Valley, Rewah. Notes from the Geological Survey of India.*

VOL. XXX, 1897.

*Part 1.*—*Annual Report for 1896. On some Norite and associated Basic Dykes and Lava-flows in Southern India (with plates I to II). The reference of the genus Vertebraria. On a Plant of Glossopteris with part of the rhizome attached, and on the structure of Vertebraria (with plates III to V).*

*Part 2.*—*The Cretaceous Deposits of Pondicherri (with plates VI to X). Notes from the Geological Survey of India.*

*Part 3.*—*Note on Flow-structure in an Igneous dyke (with plate XI). Additional note on the Olivine-norite dykes at Coonoor (with plate XII). Report on some trial excavations for corundum near Palakod, Salem District (with plate XIII). Report on the occurrence of coal at Palana village in Bikanir State (with plate XIV). An account of the geological specimens collected by the Afghan-Baluch Boundary Commission of 1896 (with plate XV). Note from the Geological Survey of India (with plates XVI and XVII).*

*Part 4.*—*On Nematite from Afghanistan. On a quartz-barytes rock occurring in the Salem District, Madras Presidency (with plate XVIII). Note on a worn femur of Hippopotamus iravadicus, Caut. and Falc., from the Lower Pliocene of Burma (with plates XIX and XX). On the supposed coal at Jaintia, Baza Duars. Percussion Figures on Micaceous. Notes from the Geological Survey of India.*

The price fixed for these publications is 1 rupee (2s.) each part, or 2 rupees (4s.) each volume.

NOTE.—*The Records ceased to be published from the 1st January 1898.*

## MISCELLANEOUS PUBLICATIONS.

**A Manual of the Geology of India. 4 Vols. With map. 1879-1887—**

- |                                       |   |         |
|---------------------------------------|---|---------|
| Vol. 1. Peninsular Area.              | } By H. B. Medlicott and W. T. Blanford | Price 8 |
| Vol. 2. Extra-Peninsular Area.        | } rupees ( <i>out of print</i> ).       |         |
| Vol. 3. Economic Geology. By V. Ball. | Price 5 rupees ( <i>out of print</i> ). |         |
| Vol. 4. Mineralogy. By F. R. Mallet.  | Price 2 rupees.                         |         |

**A Manual of the Geology of India, 2nd edition. By R. D. Oldham. (1893.) Price 8 rupees.**

**A Manual of the Geology of India, Economic Geology, by the late Prof. V. Ball, 2nd edition: revised in parts.**

Part I.—Corundum. By T. H. Holland (1898). Price 1 rupee.

**Popular guides to the geological collections in the Indian Museum, Calcutta—**

- No. 1. Tertiary vertebrate animals. By R. Lydekker. (1879.) Price 2 annas (*out of print*).
- No. 2. Minerals. By F. R. Mallet. (1879.) Price 2 annas (*out of print*).
- No. 3. Meteorites. By F. Fedden. (1880.) Price 2 annas (*out of print*).
- No. 4. Palæontological collections. By O. Feistmantel. (1881.) Price 2 annas.
- No. 5. Economic mineral products. By F. R. Mallet. (1883.) Price 2 annas.

**Descriptive catalogue of the collection of Minerals in the Geological Museum, Calcutta. By F. R. Mallet. (1883.) Price 2 rupees.**

**An Introduction to the Chemical and Physical study of Indian Minerals. By T. H. Holland. (1895.) Price 8 annas.**

**Catalogue of the remains of Siwalik Vertebrata contained in the Geological Department of the Indian Museum. By R. Lydekker, Pt. I. Mammalia. (1885.) Price 1 rupee. Pt. II. Aves, Reptilia, and Pisces. (1886.) Price 4 annas.**

**Catalogue of the remains of Pleistocene and Pre-Historic Vertebrata contained in the Geological Department of the Indian Museum. By R. Lydekker. (1886.) Price 4 annas.**

**Bibliography of Indian Geology. By R. D. Oldham. (1888.) Price 1 rupee 8 annas.**

**Report on the Geological structure and stability of the hill slopes around Naini Tal. By T. H. Holland. (1897.) Price 3 rupees.**

**Report on the inspection of Mines in India, for the year ending 30th June 1894. By James Grundy. (1894.) Price 1 rupee.**

**Report on the inspection of Mines in India for the year ending 30th June 1895. By James Grundy. (1896.) Price 2 rupees.**

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**Report on the inspection of Mines in India for the year ending 31st December 1896. By James Grundy. (1897.) Price 1 rupee.**

**Report on the inspection of Mines in India for the year ending 31st December 1897. By James Grundy. (1898.) Price 1 rupee 8 annas.**

**Report on the inspection of Mines in India for the year ending 31st December 1898. By James Grundy. (1899.) Price 12 annas.**

**Report on the inspection of Mines in India for the year ending 31st December 1899. By G. F. Reader, from notes by Mr. James Grundy. (1901.) Price 8 annas.**

**Geological map of India, 1893. Scale 1"=96 miles. Price 1 rupee.**

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To be had on application to the Registrar, Geological Survey of India, Calcutta.  
London: Kegan Paul, Trench, Trübner & Co.

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1897/98

*Geology*

# GENERAL REPORT

ON THE WORK CARRIED ON BY THE

## GEOLOGICAL SURVEY OF INDIA

FOR THE PERIOD FROM 1ST JANUARY

1897

TO THE 1ST APRIL

1898

UNDER THE DIRECTION OF

C. L. GRIESBACH, C.I.E., F.G.S., etc.



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1898.



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1898.

7/1/91  
Linnean Society of London

CALCUTTA :  
GOVERNMENT OF INDIA CENTRAL PRINTING OFFICE,  
8, HASTINGS STREET.

No. 590

To

The Secretary, Linnean Society,  
Burlington House,  
London, (England),

Dated Calcutta, the 28<sup>th</sup> July 1898.

SIR,

I have the honour to inform you that under the orders of the Government of India the "Records" issued by this Department in the months of February, May, August, and November each year, ceased to be published from the 1st January 1898.

2. Part 4 of Volume XXX supplied you, will therefore constitute the last issue of this publication.

3. A copy of the Annual Report of the Department, will in future be supplied you on issue.

I have the honour to be,

SIR,

Your most obedient Servant,

C. L. GRIESBACH,

Director, Geological Survey of India.

194

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No. 591.

To

*The Secretary,*  
*Linnean Society,*  
*Burlington House, London,*  
*(England)*

Dated Calcutta, the 28<sup>th</sup> July 1898.

SIR,

*I have the honour to inform you that under the orders of the Government of India the "Records," issued by this Department in the months of February, May, August, and November each year, ceased from the 1st January 1898 to be printed as a separate publication, and will, in future, be incorporated with the "Memoirs" of this Department.*

*2. The "Memoirs" are not published at any regular or fixed time, but whenever sufficient reports have been received to form a part. A copy of each part will be supplied you on issue.*

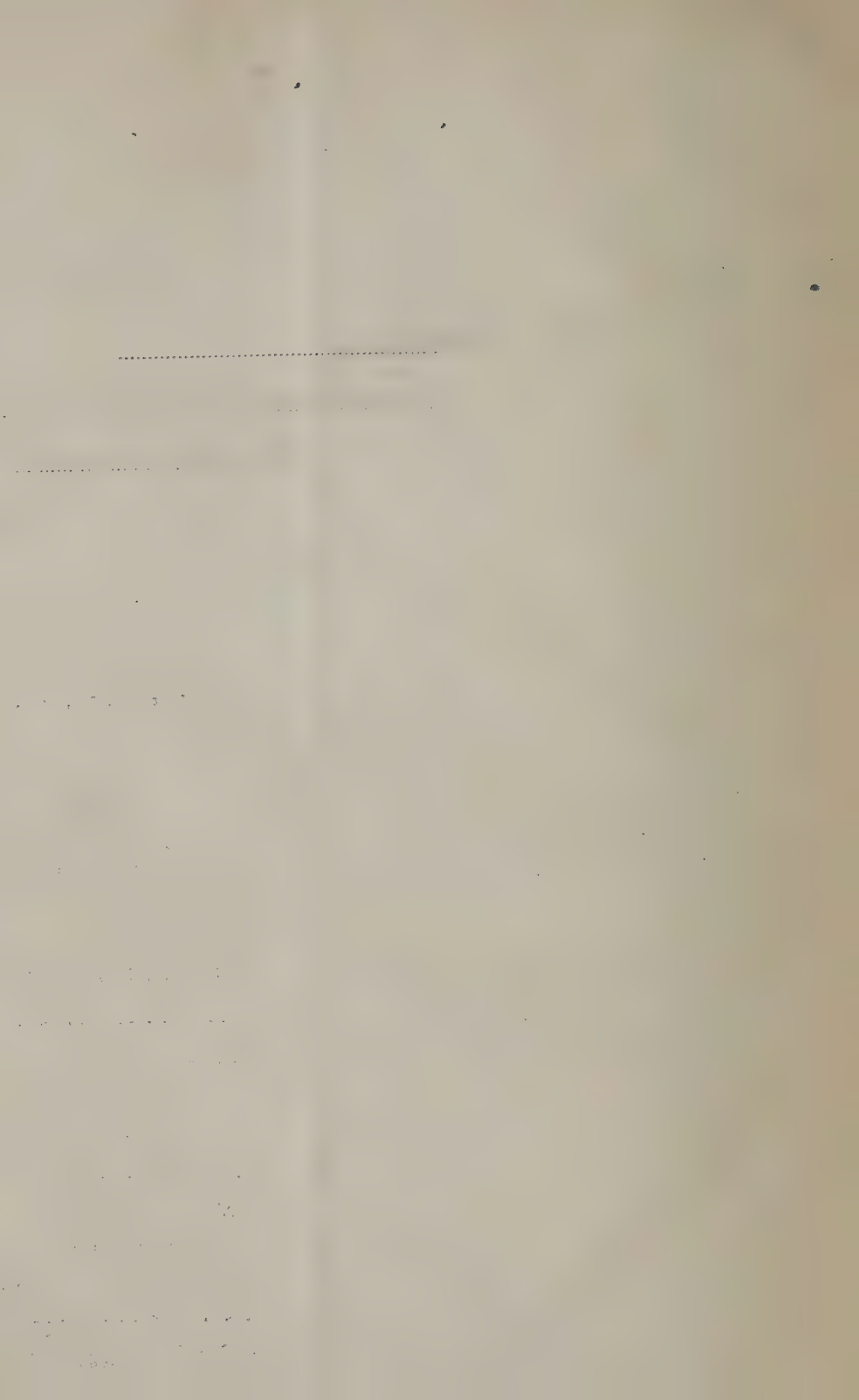
*I have the honour to be,*

SIR,

*Your most obedient Servant,*

C. L. GRIESBACH,

*Director, Geological Survey of India.*



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GENERAL REPORT  
ON THE WORK CARRIED ON BY THE  
GEOLOGICAL SURVEY OF INDIA  
FOR THE PERIOD FROM 1ST JANUARY

1897

TO THE 1ST APRIL

1898.

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PART I.—HEAD-QUARTER NOTES.

The Government of India having sanctioned that the Annual Report on the work performed by the department should be issued for the financial year instead of, as hitherto, for the calendar year, it follows that this, the first of the new issue of Annual Reports, has to embrace the entire period since the 1st January 1897.

During the greater part of this period I was absent on furlough and Mr. R. D. Oldham officiated for me.

The long impending removal of the offices of the department into the new building was carried out successfully during the hot season of 1897. The new building has been erected by the Bengal Government under an arrangement with the Trustees of the Indian Museum, and was destined to provide accommodation conjointly for the offices of the Geological Survey of India and the Indian Museum.

Although the accommodation in this new building is superior to that formerly held in the Museum building, yet there are weighty objections to it. On a former occasion<sup>1</sup> I have had an opportunity to point out the advisability of removing the head-quarters of the department to a hill-station

<sup>1</sup> Memorandum of the 29th April 1895.

and the reasons adduced in favour of such a step remain as much in force now as ever. I still entertain the hope that this will be possible at an early date and as soon as the financial position improves.

During January and February 1897 the office and laboratory were transferred into the new building, and during that period much of the work in the latter and laboratory had necessarily to stand over. After the move was completed, Mr. Hayden, assisted by Mr. Blyth, began the re-arrangement of the sedimentary rocks.

This was almost completed, so far as the Indian series is concerned, when Mr. Hayden was sent into the field. The specimens have been arranged as far as possible in chronological order, those from each area being grouped together under their respective systems. The foreign series has been separated from the Indian, and it was intended to arrange them separately in the wall cases on the north side of the rock gallery.

The collection of economic specimens has been very largely increased during the past year, chiefly by the addition of corundum from various localities in the Madras Presidency. It will consequently be necessary to re-arrange, to a certain extent, portions of the economic collection in order to find more space for this mineral. The labelling of the economic specimens has been steadily progressing—fifty-two cases have now been completed, leaving 32 still to be done.

*Minerals.*—Among the more important additions to the collection of Indian minerals are—

*Columbite.*—A fine specimen (s. g. 6.19) was presented to the museum by Mr. A. Gow Smith. It was obtained from the Koderma Government forest, Házáribágh, which is a new locality for this mineral.

*Altaite.*—A specimen of auriferous quartz containing numerous grains and specks of altaite (Pb. Te) was presented by Mr. C. P. Wright, Wuntho, Burma.

*Aluminite.*—Although this mineral had been in our collection for some time, it was not known to be aluminite, having been labelled “beauxite” by its original collector. An analysis gave the formula  $\text{Al}_2\text{O}_3, \text{SO}_3, 9\text{H}_2\text{O}$ . The specimen analysed came from Chitteedand in the Salt Range.

This is the first time that either altaite or aluminite have been recorded as occurring in India.

The following is a list of donations made to the Museum during the past year.

## Donation.

## Presented by—

Two tusks, teeth and part of skull of *Elephas Clifti*: J. Wilson, Esq., Deputy Commissioner, Rawalpindi District.  
from the Gabhir ravine, Tallaganj Tahsil, Jhelum district.

Three species of a *meteorite* that fell at Nawapali, L. S. Carey, Esq., I.C.S., Commissioner of Settlements and Agriculture, C. P.  
Sambalpur district, at 6 P.M. on June 6th, 1890,

Specimen of *Sperryllite* from Vermillion mine, Sudbury, Dr. T. L. Walker, Geological Survey of India.  
Ontario.

Specimens of *muscovite*: *muscovite w. garnet* and *tourmaline*; *pseudomorphic quartz*, in *muscovite*: a large crystal of *garnet*: 3 specimens of *columbite* from the A. Gow Smith, Esq.  
Koderma Government forest, Hazaribagh.

Specimens of *tourmaline*, *quartz* etc., from hillocks Sarat Chundra Ghosh, Chinsurah.  
near Ranchi, Chota Nagpur.

Specimens of *muscovite*, with *tourmaline* and *ferruginous inclusions*: from the Koderma Government forest, A. Gow Smith, Esq.  
Hazaribagh.

Fragment of the *Yenshi gahara meteorite* . . . Trustees of the British Museum  
through L. Fletcher, Esq.

*Nickeliferous pyrite*, from Sudbury, Ontario . . . Dr. T. L. Walker.

*Miocene fossils*, from the Upper Chindwin, Burma . . . A. Smythies, Esq., Conservator  
of Forests, Mandalay, Burma.

A collection of rocks from DeBeers Diamond mines, C. L. Griesbach, Esq., C. I. E.  
Kimberley, South Africa.

After my return to duty on the 24th November 1897, I decided to have the large collection of described type fossils re-arranged into specially constructed cases. Dr. Fritz Noetling and Mr. Hayden, who, had returned from the Tirah Field Force beginning of January, were the officers who have very ably carried out this important work, in which they were assisted by Mr. Blyth, the Museum Assistant. The work was most tedious, and required the utmost care, but the principal part of it has now been finally accomplished. Each specimen has been checked and compared with the figure given of it in our publications, and will be registered in a special catalogue, so that it can always be again referred to without any difficulty. It has now been ascertained that a number of the older specimens have disappeared, lost probably during a former removal into galleries of the Indian Museum. But the lost specimens are not very numerous and almost entirely confined to the cretaceous series of Southern India. Such loss will now be impossible, short of theft, each specimen having been marked with proper numbers painted on and corresponding to the catalogue.

COLLECTION OF TYPE  
FOSSILS.

## Assays made in the Laboratory.

Substance.	For whom.	Result.																					
One specimen of Lignite, containing plant remains and specks of resin, found at the bottom of a well, 201 feet from surface, Pallana, about 12 miles from Bikanir, Rajputana.	Lieut.-Col. H. A. Vincent, Political Agent, Bikanir.	<p><i>Quantity received, 7 lb.</i></p> <table><tr><td>Moisture</td><td>. . . . .</td><td>12'50</td></tr><tr><td>Volatile matter</td><td>. . . . .</td><td>41'40</td></tr><tr><td>Fixed carbon</td><td>. . . . .</td><td>37'50</td></tr><tr><td>Ash</td><td>. . . . .</td><td>8'60</td></tr><tr><td></td><td></td><td><hr/>100'00<hr/></td></tr></table> <p>Does not cake.</p> <p>Ash—light grey.</p> <p><i>No. 1.—From Kabul.</i></p> <p>Travertine.</p> <p><i>No. 2.—From Sakesar and Kalabagh, Punjab.</i></p> <p>Massive gypsum.</p> <p><i>No. 3.—From Kabul.</i></p> <p>Bowenite (Pseudo Jade).</p>	Moisture	. . . . .	12'50	Volatile matter	. . . . .	41'40	Fixed carbon	. . . . .	37'50	Ash	. . . . .	8'60			<hr/> 100'00 <hr/>						
Moisture	. . . . .	12'50																					
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Fixed carbon	. . . . .	37'50																					
Ash	. . . . .	8'60																					
		<hr/> 100'00 <hr/>																					
Three specimens of minerals, for determination.	Geo. Watt, Reporter on Economic Products to the Govt. of India.																						
One specimen of Psilomelane, from Gosalpur, Jabalpur district, for phosphorus.	C. W. McMinn, Jabalpur.	Contains '589 per cent. phosphoric anhydride ( $P_2O_5$ ).																					
A white mineral, found underneath the coal strata, Chittheadand, Salt Range, supposed to be Beauxite.	Museum, Geological Survey of India, Calcutta.	<p>S. G. 1'707</p> <table><tr><td><math>SO_3</math></td><td>. . . . .</td><td>23'63</td></tr><tr><td><math>H_2O</math></td><td>. . . . .</td><td>46'44</td></tr><tr><td><math>Al_2O_3</math></td><td>. . . . .</td><td>30'08</td></tr><tr><td>CaO</td><td>. . . . .</td><td>trace.</td></tr><tr><td><math>Fe_2O_3</math></td><td>. . . . .</td><td>„</td></tr><tr><td>ZnO</td><td>. . . . .</td><td>„</td></tr><tr><td></td><td></td><td><hr/>100'15<hr/></td></tr></table> <p>= Aluminite.</p>	$SO_3$	. . . . .	23'63	$H_2O$	. . . . .	46'44	$Al_2O_3$	. . . . .	30'08	CaO	. . . . .	trace.	$Fe_2O_3$	. . . . .	„	ZnO	. . . . .	„			<hr/> 100'15 <hr/>
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$Al_2O_3$	. . . . .	30'08																					
CaO	. . . . .	trace.																					
$Fe_2O_3$	. . . . .	„																					
ZnO	. . . . .	„																					
		<hr/> 100'15 <hr/>																					
Three specimens from Bishahir, supposed to be Sapphire.	R. G. Thomson, C. S., Deputy Commissioner, Simla district.	= Amethyst.																					

## Assays made in the Laboratory—contd.

Substance.	For whom.	Result.											
Six specimens of coal from the Warora Colliery.	C. O. Leefe, Assistant Secretary to Chief Commissioner, Public Works Department, Central Province, Nagpur.	Quantity received.	No. 4 pit, Far north district, 3 seam."	No. 4 pit, rise Bar district, 3 seam."	No. 5 pit, 18 rise, 3 seam."	No. 5 pit, S. A. R., 2 seam."	No. 5 pit, main dip, 3 seam."	Main dip, 2 seam."					
			10lbs.	10lbs.	10lbs.	10lbs.	10lbs.	10lbs.					
			Moisture	8'40	9'78	6'52	7'40	6'38	10'40				
			Volatile matter.	29'00	29'62	27'10	20'48	19'64	30'42				
			Fixed carbon.	42'74	43'72	40'08	36'44	31'62	41'12				
			Ash	19'86	16'88	26'30	35'68	42'36	18'06				
				100'00	100'00	100'00	100'00	100'00	100'00				
Does not cake.													
<table><tr><td>Ash—pale reddish grey.</td></tr><tr><td>Ash—reddish grey.</td></tr><tr><td>Ash—reddish grey.</td></tr><tr><td>Ash—light grey.</td></tr><tr><td>Ash—light grey.</td></tr><tr><td>Ash—light grey.</td></tr></table>								Ash—pale reddish grey.	Ash—reddish grey.	Ash—reddish grey.	Ash—light grey.	Ash—light grey.	Ash—light grey.
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Ash—light grey.													
Ash—light grey.													
One specimen of Galena, from Arki, Baghal State Simla Hills.	R. G. Thomson, c.s., Deputy Commissioner, Simla District.	Yielded on assay, 75'17 per cent. lead (Pb); and 21 oz. 1 dwt. 9 grs. silver to the ton of lead.											

## Assays made in the Laboratory—contd.

Substance.	For whom.	Result.				
		Quantity received.	I.	II.	III.	IV.
			5½ oz.	7 oz.	5½ oz.	4½ oz.
Four specimens of coal from Assam.	F. H. Smith, Geological Survey of India.	Moisture .	5'36	3'88	3'14	7'10
		Volatile matter	49'96	57'52	29'00	37'48
		Fixed carbon.	25'32	25'40	15'24	40'38
		Ash . .	19'36	13'20	52'62	15'04
			100'00	100'00	100'00	100'00
			Sinters slightly. Ash—light buff.	Sinters slightly. Ash—light buff.	Does not cake. Ash—light buff.	Does not cake. Ash—dark reddish brown.
One specimen of rock from the Jamuna river, Banda District, for identification.	S. M. Yusuffoozaman, Banda City, Indian Midland Railway.	Concretionary hæmatite; lateritic.				
Two specimens of coal, from Assam.	F. H. Smith, A.R.C.S., Deputy Superintendent, Geological Survey of India.	Quantity received.		A.	B.	
				10½ oz.	4 oz.	
		Moisture . . . . .		10'74	9'40	
		Volatile matter . . . . .		31'12	34'42	
		Fixed carbon . . . . .		25'90	26'32	
		Ash . . . . .		32'24	29'86	
				100'00	100'00	
				Does not cake.		
				Ash—white.	Ash—pale white.	

## Assays made in the Laboratory—contd.

Substance.	For whom.	Result.										
One specimen of lignite with specks of resin, from Pallana, 12 miles from Bikanir, Rajputana.	Tom.D.La Touche, B. A., Superintendent, Geological Survey of India.	<p><i>Quantity received, 45lbs.</i></p> <table><tr><td>Moisture . . . . .</td><td>8.20</td></tr><tr><td>Volatile matter . . . . .</td><td>42.72</td></tr><tr><td>Fixed carbon . . . . .</td><td>30.48</td></tr><tr><td>Ash . . . . .</td><td>9.60</td></tr><tr><td></td><td><hr/>100.00<hr/></td></tr></table> <p>Sinters slightly, but does not cake.</p> <p>Ash—light brown.</p> <p>Calorific power in heat units (C), 7,293.</p> <p>Evaporative power, 13.58.</p>	Moisture . . . . .	8.20	Volatile matter . . . . .	42.72	Fixed carbon . . . . .	30.48	Ash . . . . .	9.60		<hr/> 100.00 <hr/>
Moisture . . . . .	8.20											
Volatile matter . . . . .	42.72											
Fixed carbon . . . . .	30.48											
Ash . . . . .	9.60											
	<hr/> 100.00 <hr/>											
Sixty specimens of quartz-barytes rock, from Tirupattar Taluk, Salem District, Madras, for an analysis of the Barytes; determination of the proportion of barytes and quartz; and an assay for gold.	C. S. Middlemiss, B.A., T. H. Holland, A.R. C.S., F. G. S., Supdts., Geological Survey of India.	Results to be published in Records, Vol. XXX, part 4, in a paper by C. S. Middlemiss and T. H. Holland.										
Fragments of a rock for determination.	Col. H. A. Sawyer, I.S.C., 45th B.I., Malakand.	The fragments consist of quartz, felspar and muscovite, apparently derived from the disintegration of granite.										
A specimen of iron pyrites from the Malakand, to know what it is embedded in.	Surgeon-Captain, D. St. J. D. Grant, M. B., Chemical Examiner to Government, Medical College, Lahore.	The matrix is limestone.										
A specimen of "metal something like lead or plumbago", from Belbathan, for determination.	R. Carstairs, I.C.S., Deputy Commissioner of the Sonthal Parganas, Dumka.	Galena. A specimen from the same locality, received in 1889, yielded on assay 77.29 per cent. of lead; and 13 oz. 17 dwts. 16 grs. of silver to the ton of lead.										
A heavy metallic looking specimen from the Koderma Government Forest, Hazaribagh District, supposed to be iron.	A. Gow-Smith, Hastings House, Alipore.	Columbite; S. G. 6.19.										
Two specimens of minerals, washed from soil, for determination.	J. Walter Leather, Agricultural Chemist to the Government of India, Dehra Dun.	Both specimens, impure lemonite.										

## Assays made in the Laboratory—contd.

Substance.	For whom.	Result.																																																																																										
Quantity received, 14 lbs.																																																																																												
Pebbles of schist containing quartz from the Wa States, Upper Burma, for gold.	The Chief Secretary to the Government of Burma, Rangoon.	Yielded on assay, 10.5 grains of gold to the ton.																																																																																										
"Substances that came out of the earth along with sand and water, on the north and east banks of the Brahmaputra, during the earthquake of 12th June 1897."	Hiranmoy Mukerjee, Muktagacha, Mymensing District.	Lignite, resin and micaceous sand.																																																																																										
"A piece of black substance and some resinous-looking stuff that came out from an earthquake fissure at Mankar Char on the east bank of the Brahmaputra."	The District Engineer, Rungpur.	One of the specimens is a form of lignite, the other a resin.  The lignite was probably derived from the disintegration of beds containing that mineral and similar to those seen in the Garo Hills.																																																																																										
Six specimens of minerals from the vicinity of North-West Baluchistan.	T. Webb-Ware, Political Assistant, Chagai-Quetta.	1. Sulphur. 2. Sulphate of alumina. 3. Galena. 4. Micaceous iron. 5. Red ochre. 6. Yellow ochre.																																																																																										
A specimen of granite from Urumalia quarry, 1/2 mile south-west of Karasamir, South Arcot District, Madras.	T. H. Holland, A.R.C.S., F.G.S., Offg. Superintendent, Geological Survey of India.	No. 9785.  Specific gravity 2.818.  <table><tr><td>SiO</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>58.30</td></tr><tr><td>Al<sub>2</sub>O<sub>3</sub></td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>20.76</td></tr><tr><td>Fe<sub>2</sub>O<sub>3</sub></td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>2.59</td></tr><tr><td>FeO</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>3.84</td></tr><tr><td>CaO</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>8.38</td></tr><tr><td>MgO</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>2.62</td></tr><tr><td>Na<sub>2</sub>O</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>4.21</td></tr><tr><td>K<sub>2</sub>O</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.71</td></tr><tr><td>Loss on ignition</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>20</td></tr></table>	SiO	.	.	.	.	.	.	.	.	58.30	Al <sub>2</sub> O <sub>3</sub>	.	.	.	.	.	.	.	.	20.76	Fe <sub>2</sub> O <sub>3</sub>	.	.	.	.	.	.	.	.	2.59	FeO	.	.	.	.	.	.	.	.	3.84	CaO	.	.	.	.	.	.	.	.	8.38	MgO	.	.	.	.	.	.	.	.	2.62	Na <sub>2</sub> O	.	.	.	.	.	.	.	.	4.21	K <sub>2</sub> O	.	.	.	.	.	.	.	.	.71	Loss on ignition	.	.	.	.	.	.	.	.	20
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101.61																																																																																												

## Assays made in the Laboratory—contd.

Substance.	For whom.	Result.
A specimen of hypersthene hornblende granite from Perumbakam, Madras.	T. H. Holland, A.R.C.S., F.G.S., Offg. Superintendent, Geological Survey of India.	No. 9791.
		Specific gravity 2.787.
		SiO <sub>2</sub> . . . . . 61.40
		Al <sub>2</sub> O <sub>3</sub> . . . . . 19.38
		Fe <sub>2</sub> O <sub>3</sub> . . . . . 5.58
		FeO . . . . . 5.27
		CaO . . . . . 6.56
		MgO . . . . . 3.24
		Na <sub>2</sub> O . . . . . 2.78
		K <sub>2</sub> O . . . . . .44
		Loss on ignition . . . . . 15
		99.08
Alkaline salt from Yenangyat, Upper Burma, occurring as an incrustation.	G. F. Grimes, A. R. S. M. B. S. C., etc., Assistant Superintendent, Geological Survey of India.	Soluble in hot water.
		Na <sub>2</sub> O . . . . . 34.89
		K <sub>2</sub> O . . . . . 2.24
		CaO . . . . . 1.25
		MgO . . . . . 1.80
		SiO <sub>2</sub> . . . . . 48.09
		Cl . . . . . .32
		Loss on ignition . . . . . 4.65
		Insoluble in hot water . . . . . 10.00
		101.24
		Less oxygen equivalent . . . . . 08
		101.16
A specimen of elæolite from elæolite syenite, from Sivamalai, Coimbatore district, Madras.	T. H. Holland, A.R.C.S., F.G.S., Offg. Superintendent, Geological Survey of India.	No. 11464.
		Specific gravity 2.62.
		SiO <sub>2</sub> . . . . . 43.35
		Al <sub>2</sub> O <sub>3</sub> . . . . . 34.32
		Fe <sub>2</sub> O <sub>3</sub> . . . . . 1.02
		CaO . . . . . .82
		K <sub>2</sub> O . . . . . 5.52
		Na <sub>2</sub> O . . . . . 14.62
		Loss on ignition . . . . . 75
		100.40
Two pieces of stone found while sinking a well in Jugdispur Tatarpur, Chupra, Sarun district, for determination.	E. P. Chapman, c.s., Officiating Magistrate of Sarun.	Calcite.
A piece of igneous rock from a boring 270 feet deep in Kabwet, Upper Burma.	The Agent and Manager, Burma Coal Co., Ltd., Kabwet, Upper Burma.	Dolerite.

## Assays made in the Laboratory—concl'd.

Substance.	For whom.	Result.
Nineteen specimens of rocks and minerals, from the Banda district, for determination.	R. M. Thompson, Public Works Department, Banda.	(1) Granitoid gneiss. (2) Gneiss. (3) „ (4) Pegmatite. (5) „ (6) „ (7) Probably decomposed syenite. (8) „ „ „ (9) Quartz. (10) „ (11) „ (12) „ (13) Amethyst. (14) Chalcedony. (15) „ (16) Breccia of flint fragments. (17) Siliceous sinter. (18) Hornblende gneiss. (19) Flint.
A specimen of coal taken from the diamond drill boring in the vicinity of the Eeb bridge on the B. N. R., Rampur coal-field.	The Junior Consulting Engineer to the Government of India for Railways, Nagpur.	A piece of the core taken from between the 429th and 430th foot, weight 12 oz. Moisture . . . . . 5'30 Volatile matter . . . . . 27'74 Fixed carbon . . . . . 49'78 Ash . . . . . 17'18 <hr/> 100'00 <hr/> Sinters slightly, but does not cake. Ash—dark reddish brown.
Sand found in a nala near Chumbal River.	Col. D. G. Pitcher, I.S.C., Director of Land Records, Gwalior State.	Garnet sand.
Mineral found in Government land in the Darjiling district supposed to contain copper.	Mr. Finucane, C.S.I., Secretary to Government of Bengal,	Mixture of iron and copper pyrites.

Dr. Noetling was absent on furlough till June 1897; after his return to duty he set to work at the determination and description of the large collection of Burman fossils in the Museum, in part collected by himself and in part by former workers in Burma, as for instance Messrs. Theobald, Blanford, Fedden, Dr. Oldham and later by Mr. Grimes. After weeding out useless and doubtful specimens, a fine collection of tertiary fossils remained, of which part, including the Antozoa, Echinodermata and Pelecypoda, has been described and is awaiting publication.

The results of the examination of the Pelecypoda are highly interesting and unexpected. It has hitherto been laid down as an axiom that the fauna living at present in the Indian ocean is closely related to the tertiary fauna of Europe. The tertiary Pelecypoda of Burma have, however, proved the absolute fallacy of this theory. For the majority of the species examined are either identical with species now inhabiting the Indian ocean, or are so closely related to living species that it seems impossible to avoid the conclusion that the latter are the direct descendants of the former. On the other hand, not a single species from Burma could be identified with any one from the tertiary system of Europe. There are a certain number of species which are identical with species which occur in the miocene of Java and Sumatra, and a smaller number still which are identical with species from the tertiary of Sind, but no relationship with the tertiary fauna of Europe could be discovered.

Two important facts are therefore almost proved by the examination of the tertiary Pelecypoda of Burma, *viz.*, (1) the fauna of the Indian Ocean is an old one, (2) no connection existed between the fauna of the upper tertiary, Indian ocean, and the upper tertiary, European ocean.

With regard to the first part there remains little doubt that the composition and facies of the fauna which lived during the upper tertiary period in Burma was exactly the same as the one now inhabiting the Indian ocean. The present fauna exhibits therefore not a modern type, but more properly speaking an older tertiary type. Further, if the present fauna of the Indian ocean bears the strongest relationship to the tertiary fauna of Burma, while the latter bears no relationship to the tertiary fauna of Europe, it is impossible that the living fauna of the Indian ocean can exhibit any relationship to the tertiary fauna of Europe. It is therefore not only very probable, but almost certain, that no connection existed between the Indian ocean of the upper tertiary period, and the European ocean of the same time. The fauna of the Indian ocean developed independently of that of Europe since the upper tertiary period, but it is most remarkable, that while the terrestrial fauna which lived at the same time, and somewhat later on the Indian continent, underwent tremendous changes; the marine fauna did not change its habitus in the least, in fact, it might almost be said that hardly the species changed their aspect.

Under the above circumstances the question of the age to which the fauna described, belongs, becomes somewhat uncertain. There is no question about its belonging to the upper tertiary period, but whether it represents the miocene of pliocene period seems somewhat doubtful. Without entering into a lengthy discussion on the original definition of the terms miocene and pliocene the question could not be settled, but it appears very possible that the marine fauna of the upper tertiary of Burma represents the pliocene and very probably also the lower pliocene period. This would in some way explain the seemingly strange fact, that it has so few species in common with the tertiary beds of Sind, if we assume that the latter are of older age.

These views will of course be further dealt with when the whole of the fauna has been described, but, as already stated, the present examination has opened a road which leads towards new and unexpected results, in fact it tends to change the view hitherto held on the origin of the fauna of the Indian ocean. As an outcome of the specific examination of the tertiary fauna of Burma, two papers dealing with the morphology of the shells of the Pelecypoda have been submitted for publication, as the questions therein dealt with could not conveniently be included in a systematic description of the species.

Mr. H. B. Wade Garrick, the Artist of the Department, reports that forty-seven lithographic plates have been prepared and 21,810 prints have been pulled off in the lithographic press of the Geological Survey of India, also 27 designs have been drawn on wood ready for the engraver.

In the map branch, a large number of geological boundaries have been transferred from field sheets and old M. S. maps, and compiled on to fair sheets to be kept for record in the office, and some maps printed by the Survey of India have also been coloured by our colourists.

Work of a miscellaneous nature has also been done, such as lithographed labels required for the laboratory, etc.; plates not intended for publication; pen drawings made for reproduction by photography, and lithographic practice work during spare time, etc. Finally, in connection with the Earthquake Report, a pen diagram has been made showing the river levels of the Ganges and Brahmaputra at Goalundo and Gauhati respectively during the years 1895, 1896 and 1897. This has been drawn to scale from the figures in the Irrigation Report of the Public Works Department, Bengal.

The additions to the Library during the year under review amount to 3,143 volumes and parts of volumes, of which 2,266 were acquired by presentation, and 877 by purchase.

#### *Publications.*

The third part of the first edition of the Manual of Geology of India, which was prepared by the late Dr. V. Ball in 1881, has for several years been out of print. The preparation of a new edition on the same plan as the original

*The Manual of the  
Geology of India.*

one would involve a greater interruption of the regular work of the survey than can at present be contemplated, and it is doubtful whether the result would be commensurate with the expenditure of time involved. Many minerals are of little economic interest at present, and the additions to our knowledge since the publication of Dr. Ball's volume are small, yet to bring these up to date would involve almost as much work, in many cases, as the revision of these parts dealing with minerals, such as mica, which have risen to an importance unthought of and regarding which our knowledge has been revolutionised rather than advanced.

Under these circumstances, and in view of the frequent applications for general information regarding specific minerals, a scheme of re-issue of this part of the manual by instalments has been sanctioned by Government. Each instalment will deal with a single mineral, or group of closely allied minerals, and in the first instance these will be selected with regard to which there has been the greatest change in the state of our knowledge since 1881. In this way, it is hoped that gradually, and without interrupting the regular work of the survey, it may be possible to re-issue the Manual of the Economic Geology of India, or at any rate such parts as are of sufficient interest to justify this course.

As a commencement, corundum and its gem forms ruby and sapphire was selected, and a handbook has been prepared by Mr. Holland treating on these minerals and giving a full account of all that is known at the present day regarding their occurrence in India. This has been passed for press and will be issued forthwith.

With the volume XXX of the "Records," this publication has ceased to exist as a separate serial of the Department, it having been found inconvenient to bring out reports at regular stated periods. In future all papers which were formerly brought out in the "Records" will be published in the "Memoirs" and "parts" of the latter, as matter for publication accumulates, will be issued at irregular intervals and grouped into volumes as heretofore.

The following "Memoirs" have been published since the 1st January 1897 :—

Vol. XXVII, part 2.—The occurrence of Petroleum in Burma and its technical exploitation, by Dr. F. Nœtling.

The "Palæontologia Indica," which is at present arranged into so-called series, will in future be published in parts, and these be grouped into consecutive volumes of convenient size, containing palæontological reports, each complete in itself and as they are sent in, thus obviating the necessity of publishing descriptions of small collections in the "Memoirs," as often had to be done on former occasions when such papers could not be included in any one of the "series."

Such of the "series" which are not yet complete, as for instance the "Himalayan fossils," series XV, will of course be brought to a conclusion.

The following parts of the "Palæontologia Indica" have been issued since 1st January 1897 :—

Series XV, Vol. I, parts 3 and 4,  
Vol. II, part I,

both of the Himalayan Fossils.

Series XVI, Vol. I, parts 2 and 3,  
of the Baluchistan Fossils.

A large number of geological maps on various scales and of different districts have been published in the Memoirs and

*Geological maps.* Records of the Department, but as no general index of these has been prepared, it was impossible for strangers to know whether a geological map of any district in which they were interested was procurable or not. The number of applications for geological maps received shows that this was a real want, and two index maps have been prepared during the recess of 1897 under the superintendence of Dr. Walker, which show respectively the areas which are published on scales of four miles or less to the inch, and on the smaller scales of more than four miles to the inch; the area included in each map, and the volume and part with which it was published.

I rejoined and took over my office from Mr. Oldham on the 24th November of last year. I utilized the first nine months of my furlough to proceed to South Africa, in order to study the gold-bearing rocks of that part of the world, but chiefly those of the Transvaal, and also the conditions of the mining laws and industry of that country. Although this enquiry was of a private nature and carried out during absence on furlough, I refer to it here on account of its bearing to Indian conditions. I intend compiling a special report on the subject of the enquiry at a subsequent date.

Besides myself, the following officers were on leave during the period under report and rejoined on the dates mentioned below :—

Mr. Bose	.	.	.	rejoined 15th May 1897.
Mr. Datta	.	.	.	do. 17th March 1898.
Dr. Noelling	.	.	.	do. 26th June 1897.

Sub-Assistant Hira Lal is on leave from the 6th September 1897.

Mr. William Anderson resigned his appointment as Mining Specialist on the 15th October 1896.

Dr. Thomas Leonard Walker joined the Department as Assistant Superintendent on the 8th May 1897.

## Part II.—Field parties.

*Distribution of the officers.* During the period under report the distribution of the staff of the Department was as follows :—

Mr. R. D. Oldham . . . . . Officiating Director up to 24th November 1897; then on field work in Assam.

Mr. LaTouche . . .	Western Rajputana; 1896 to 1897 head-quarters and Assam, Western Rajputana 1897 to 1898.
„ C. S. Middlemiss . . .	Madras; Salem and Coimbatore districts.
„ Bose . . . . .	Returned from furlough on the 15th May 1897; head-quarters and Eastern Bengal; cold weather season in the Central Provinces.
„ Holland . . . . .	Madras; Salem district and Coorg.
„ Datta . . . . .	Returned to duty on the 17th March of this year; head-quarters.
„ Smith . . . . .	Assam and Central Provinces.
„ Hayden . . . . .	Headquarters, Assam and the North-Western Frontier.
„ Vredenburg . . . . .	South Rewa, Assam and Bhopal.
„ Grimes . . . . .	Burma and Assam.
„ Walker . . . . .	Joined the Department on first appointment on the 8th May 1897, and is attached to Mr. Holland in Coorg.
Lala Hira Lal . . . . .	Chota Nagpore head-quarters; and furlough from 1897.
„ Kishen Singh . . . . .	Bombay Presidency.

The officers of the Department were grouped into the following parties during the period under report:—

*Field parties.*

Earthquake inquiry . . . . .	Mr. Oldham.
	„ LaTouche.
	„ Bose.
	„ Smith.
	„ Hayden.
	„ Vredenburg.
	„ Grimes.

Madras Presidency—

Salem and Coimbatore districts . . . . .	Mr. Middlemiss.
	„ Holland.
Coorg . . . . .	„ Holland.
	„ Walker.
Bombay Presidency . . . . .	Lala Kishen Singh.
Rajputana Agency . . . . .	Mr. LaTouche.
Central India Agency . . . . .	„ Vredenburg.
Central Provinces . . . . .	„ Bose.
	„ Smith.
Assam . . . . .	„ Smith.

Burma . . . . . Mr. Grimes.

North-West Frontier . . . . . „ Hayden.

### 1. Earthquake inquiry.

A great event which affected the Department, may be referred to as the “great earthquake” of the 12th June 1897. As it turns out now, it forms one of the largest, perhaps the most extensive phenomenon of the kind known to mankind, at least as regards the great land-area over which it was felt. Government decided that a most searching inquiry, followed by a full report, should be instituted, and with that end in view all officers of the Department who were then available, were deputed to various parts of Assam and Bengal to observe and investigate the effects of the earthquake; Messrs. LaTouche, Bose, Smith, Hayden, Vredenburg and Grimes were engaged on that work, and in addition Mr. Oldham made two short trips into the disturbed country in August and October last year, and during the last field season he was engaged in traversing parts of the Garo and Khasia Hills, where the centre of the disturbance was, in order to study certain effects of it in greater detail, which may help in forming an explanation of the probable causes of the earthquake. He has been charged with the working out of all the reports and studies into a fully illustrated description of the event, which will be published in the memoirs of the Department.

At the same time orders were issued by Government to the local authorities to report fully on the effects of the earthquake. All the telegraph offices throughout India were instructed to report the time at which it was felt, and similar information was called for from all the station-masters on the line of railways within the area likely to be affected. Circulars have also been widely distributed and communicated to the press, which has readily assisted in the endeavour to collect information.

Mr. Oldham has sent in several very interesting notes during the progress of his inquiry, together with a short paper which is given here.

“At first there was a natural tendency to associate the earthquake with the great flexure which skirts the southern edge of the Assam range. This was believed to be a region of tectonic movement, while the plateau to the north

was regarded as a more stable region.

The existence of the depression of the Brahmaputra valley shows that this region has, in geological recent times, been subject to extensive changes of level, but the tendency to regard its southern edge as the principal zone of movement, in view of the geological structure and orographical relief of the region, probably represents the truth. From this it was a natural step to conclude that what had been a zone of greatest movement in recent times, was also the zone along which the forces of the earthquake must be looked

*Mr. R. D. Oldham on  
the earthquake.*

for. At a very early stage in the investigation of the earthquake this conclusion became questionable. It was found that if the centre was placed anywhere along the southern edge of the hill, there was a most unaccountably rapid falling off in intensity of the disturbance in a southerly as opposed to a northerly direction. Further, as soon as it was possible to arrange for some sort of a record of the aftershocks, it was found that at stations along the northern edge of the hills they were extremely abundant, so much so that in preparing a list of aftershocks, I found it necessary to exclude the returns from Goalpara and all places south of the Brahmaputra in that district, as well as those from Shillong and Tura. All this region was subject to a number of small shocks which did not spread beyond it and which seemed to be for the most part very local in their extent even within the region lying between the three stations mentioned.

From these facts, the supposition, that the centre of the earthquake lay along the southern edge of the hills, was discredited and we had to look for it further north, but as the scanty knowledge of the geology of the northern part of these hills gave no indication of any leading tectonic feature, there was nothing to guide us to a conjecture as to the exact position, and I was deputed to examine the Khasi and Garo Hills during the working season of 1897-98 with a view to the filling in of this blank. In spite of the limited time and the forest-clad nature of the country, which practically forbids any deviation from the beaten tracks, some important results have been obtained.

In the eastern part of the Garo Hills, and about the centre of the range, there are several pools which have been formed by a reversal of the slope of the stream beds. They vary in size, the largest being about  $1\frac{1}{2}$  miles long and 18 feet deep, the other smaller. In many cases these, so far as I could discover, did not owe their origin to a fault appearing as such at the surface, the stream bed has been elevated, or depressed, in a gentle roll, and as the streams flow in rock beds this must be due to a deep-seated deformation of the surface. Towards the northern edge of the hills I found some faults which appeared as such at the surface. Omitting the smaller ones, to which some doubt attaches, there are two principal ones: one at the Samin can be traced for about  $2\frac{1}{4}$  miles with a general direction of N. W. by W. and a maximum throw of 9 feet at the surface; the other in the Chedrang Valley has been traced for 12 miles before it becomes lost under the alluvium of the Brahmaputra valley at Jhira Hat. The throw varies largely and will fall from 20 feet to nothing within a few hundred yards; the maximum actually measured was 32 feet.

This fault in itself would be sufficient to account for an earthquake of the first class of magnitude, but it is only a small part of the cause of that of 12th June 1897. There are the other disturbances of the surface to be considered, and in assigning a cause to the earthquake we must either regard each displacement as the sign of a separate focus and the earthquake itself as a

compound one, consisting of a number of earthquakes which all occurred at once; or we may regard these surface displacements as themselves only secondary and indications of a more general and simple disturbance.

There is one, and so far as I can see, only one, supposition which would explain all the facts, and that is the existence, or the creation, of a nearly horizontal fracture or *thrust plane* along which the upper part of the earth's crust was pushed over the lower. This plane would nowhere come to the surface and the movement of the upper layer against the undisturbed crust beyond the limits of the fracture would give rise to just that compression which would account for the conspicuous displacements of surface levels seen in the eastern part of the Garo Hills District, and less conspicuously to the east and the west.

In this conclusion, we find an easy explanation of the area over which the shock had a maximum of destructive energy, without postulating an improbable depth for the focus. There is no necessity or reason to suppose that the thrust plane lies at any great depth from the surface, and it is possible that 5 miles may represent a maximum rather than a minimum value, but what the focus loses in depth it gains in area.

The eastern limit of this thrust plane extended to, but probably not much beyond the meridian of Shillong. To the west it probably extends under the alluvium of northern Bengal, perhaps as far as E. Long.  $89^{\circ}$  or a distance of about 180 miles. The breadth from north to south is 35 miles within the Garo hills, in the eastern part of the district, and to the north it extends under the alluvium of the Assam valley, possibly for as far again. These dimensions, 180 miles by 70 miles, must be taken as extreme limits, which is at present no reason to suppose were greatly exceeded. It seems certain that the thrust plane had its greatest width, and consequent greatest movement, in about E. Long.  $91^{\circ}$  or a little to the west, but permanent displacements of lesser extent have been recognised throughout the rock area within the limits mentioned. Outside the hills, in the alluvial plain, permanent displacements are marked by the surface disturbance of the alluvium and the extent of the epi-centre is largely a matter of inference; but the main conclusion is well established, that the origin of the disturbance was not confined to a spot or a line, but extended over a large area.

## 2. Surveys in the Madras Presidency.

The survey of the Salem and Coimbatore Districts, which under Mr. Middlemiss's superintendence has been going on since December 1893, and which before that time had been conducted intermittently by Mr. Holland, should have been finished some time during 1897, but owing to the importance of the work, demanded another season to more or less finish it. Mr. Middlemiss will now prepare a detailed report on his investigation, which

were largely of an economic character, which report may be expected to be completed during the cold season of this year. Until Messrs. Middlemiss and Holland hand in their reports it is almost impossible to give a fair summary of their labours. The survey<sup>1</sup> could not be carried on systematically as in other parts of India, the nature of the work demanding constant changes from one special inquiry to the other, but I fully expect that the final result of the work will afford a valuable key to the interpretation of the rocks of South-ern India, such as the Department has never obtained before.

The survey of the eastern part of the Tirupatur taluq, Salem District, which had been begun in December 1896, was continued during the first three months of 1897, and that of the Javadi hills has been continued. The most interesting result has been the discovery of a number of veins of a rock composed of quartz and barytes. The rock shows none of the parallel arrangement of the minerals usual in mineral veins, and has, in the field, all the appearance of an intrusive rock. Apart from its mode or occurrence which is that of a true pegmatite, there does not seem to be any ground for supposing that the barytes is a pseudomorph after orthoclase, and the field evidence points to the conclusion that the barytes was an original constituent of the rock, but whether the rock is an altered form of pegmatite or not, it is a remarkable and probably unique occurrence of barytes.

In Messrs. King and Foote's memoir on the Salem, etc., districts (IV, p. 271) reference is made to a form of gneiss which has the appearance of being penetrated by a net work of veins of trap, to which the name 'trap-shotten' was applied. These rocks have been examined, and in the opinion of Mr. Holland the dark coloured veins are not due to the injection of basic trap, but to the partial fusion of ferruginous veins of hydrous minerals (epidote, etc.) by the heat produced during the movements by which the rock has been shattered along the lines where the 'trap-shotten' gneiss is found.

A glassy looking mineral has been found in a dyke of pegmatite S. W. of Andiappanur. It is yellow brown in colour practically isotropic and has a sp. gr. of 3.45 in slightly altered specimens. Its characters have not yet been worked out, but it is almost certainly one of the minerals composed largely of the rare earths. Although it resembles tseheffkinite in appearance, its specific gravity more nearly approaches that of keilhauite and allanite.

The preliminary investigation of the corundum bearing rock near Palakod has been closed and a report submitted, which will be published in due course. Three lenticles have been found within a distance of 25 yards along the strike. From this it would

<sup>1</sup> During the course of the survey, besides the officers who were actively engaged on the work this year, Messrs. Warth and Smith were also employed on it.

seem that there is no lack of corundum so far as quantity goes. Two samples of 20lb. each, accompanied by samples of the rock, have been sent to the Imperial Institute, through the Reporter on Economic Products to the Government India, for valuation and report. Another sample has been sent to Messrs. Lyall, Marshal & Co., of Calcutta, who have kindly agreed to have the sample valued and reported on by their correspondents in America, and three samples have been sent to Messrs. Binny & Co., Perry & Co., and Dymes & Co., of Madras. On receipt of the reports on these samples it will be possible to judge whether there is any prospect of working the rock at a profit.

In the course of the survey the iron ores of the Javadi hills were examined.

*Iron ore.*

The result shows that the upper parts of the ridge contain several beds of magnetite with hæmatite and quartz of the same general arrangement and appearance as those of the Kanjamalai and Tirtamalai. At the western base of the hills the mottled gneiss ascends about one-third of their height. Then comes hornblendic gneiss and a series of magnetic iron beds interbedded with hornblendic, micaceous, garnetiferous and hypersthene-bearing gneisses. These bands of iron ore all run N. N. E. and S. S. W. parallel to the run of the ridge and are marked by prominent ridges and platforms standing out from the slopes. The lowest and most prominent, about 100 feet thick, has been traced from Monellimalai, near Pudur to Methamalai, S. E. of Alangayam—a distance of 16 miles—and a large number of specimens have been taken for analysis and distribution.

After a short recess season, field work was resumed in the Coimbatore district on 18th June 1897. In the neighbourhood of

*Elæolite-bearing rocks.*

Kangayam, elæolite-bearing rocks have been found, containing crystals of elæolite 3 or 4 inches in diameter. The prevalent rock is described as fine grained and darkened in colour by the abundance in it of magnetite, graphite and ferromagnesian silicates, amongst which biotite and hornblende are the prevailing forms. This rock is cut through by coarse grained veins composed of elæolite and felspar with smaller quantities of graphite biotite and green apatite. Mr. Holland regards this rock as genetically connected with the corundum of Kangayam. He refers to Morozewicz's artificial production of corundum by the devitrification of slags containing over 30% of alumina and rich in alkalis; and points out that the elæolite contains over 33% of alumina, and is in great excess amongst the rock constituents.

The quartz-magnetite schists near Uttukuli and Viziamangalam Railway stations were examined and found to be associated with calciphyres and pyroxenic and garnetiferous granulites. Similar schists are associated with hornblende-norite at Madukarai, 7 miles south of Coimbatore, where the well known coccolitic marbles appear to be associated with pyroxene scapolite granulites similar to those associated with the ruby-bearing limestones of Burma.

Mr. Middlemiss was principally engaged in the survey of the neighbourhood of Coimbatore. He finds the lowest-lying rocks of the region to consist of a well foliated gneiss composed of quartz felspar and black mica. The foliation of this rock is bent into two long and gentle anticlines with a shallow syncline between them. On either hand to the north and south they pass under a series of basic and ultrabasic rocks which again pass upwards into normal charnockites. Lambton's peak near Coimbatore, lies on a sharp syncline; the lower slopes are formed by the more basic members of the charnockite series, while the higher crags are composed of paler coloured and more acid members of the same series of rocks.

Mr. Holland was engaged in the examination of the neighbourhood of Salem and part of the Shevaroy hills. The Shevaroy hills are composed of rocks of the charnockite series, principally the intermediate type which form the bulk of all the larger exposures; a trap dyke can be traced in a north-west to south-easterly direction right across the hills, but becomes lost on reaching the schists of the Salem-Atur valley. Seven miles off to the south-south-east a dyke of the same rock running in the same direction is found, but the continuation would lie  $3\frac{1}{2}$  miles to the south-west of the Shevaroy dyke. It is doubtful whether these can be regarded as continuations of the same dyke, broken by faulting, and it is more probable that they are independent dykes of the same composition.

On the west side of the Shevaroy hills Mr. Holland finds the normal charnockite abruptly cut off and replaced by the varied rocks of the low ground, amongst which the most prominent forms are highly garnetiferous hornblende pyroxene granulites. The line of separation is probably a fault, which runs northwards from Salem towards the chalk hills, and Mr. Holland suggests that it probably determined the precise locality of the peridotite outbursts of that area. It may also be suggested that this fault line may be genetically connected with the elevation of the Shevaroy hills, and that they may owe their existence, in part at least, to special elevation, and not solely to the greater resistance to denudation offered by the rocks of which they are composed:

(1) First part was spent in the southern parts of Coimbatore district in the

Mr. Middlemiss's  
work during the cold  
weather, season 1897 to  
1898.

*Animallai hills.*

*Hornblende-biotite  
gneiss.*

*Horizontal or gently un-  
dulating strata.*

*Porous soil.*

difficultly accessible parts of the *Animallai hills*, which were entered along 3 lines, giving 3 cross sections. Owing to dense forest the work was difficult and slow. The results showed that these hills do not in the least resemble the Nilgiris geologically, being composed for the most part of a very *quartzose hornblende biotite gneiss* well foliated, in great horizontal or

gently undulating beds forming magnificent *scarps* and *plateaux* above, the latter of which at elevations of 3,000—4,000 feet are now being extensively

opened out for coffee planting. From the fact that the rock is different from that of the Nilgiris and weathers into an extremely light porous soil I anticipate a great success to the planting community:

Only a few minor layers in the gneiss yield a little *augite*, and *hypersthene*

Augite and hypersthene  
gneiss.

veins of pegmatite occur, but no basic dykes are found in this part of the country.

(2) Examined the *Kanjamallai* hill near *Salem*, for the purpose of

Kanjamallai Iron Ores.

selecting 2 tons iron ore for despatch to England (see special report sent in).

Railway cutting, etc.

(3) *Railway cuttings* between *Coimbatore* and *Sankaridrug* examined by trolley.

(4) *Sethurama Rao*, the native assistant of the party, finished mapping some parts near *Kaveripuram* and the hills N. E. *Sankaridrug*. *S. Rao* had accompanied *Mr. Middlemiss* for about two years as an assistant, temporarily employed, and he seems to have shown great zeal and usefulness in certain details of work.

MR. T. H. HOLLAND,  
Work during the seasons  
1896 to 1897.

As a result of his investigation in the *Salem* and *Coimbatore* districts of *Madras*, *Mr. Holland* has compiled three reports :—

1. The *Charnockite* series of *South India*.
2. On an *elæolite-syenite* containing *graphite*, and associated with *corundum*, in the *Coimbatore* district.
3. The geology of the *Shevaroy* hills and the neighbourhood of *Salem*.

The following is extracted from these papers :—

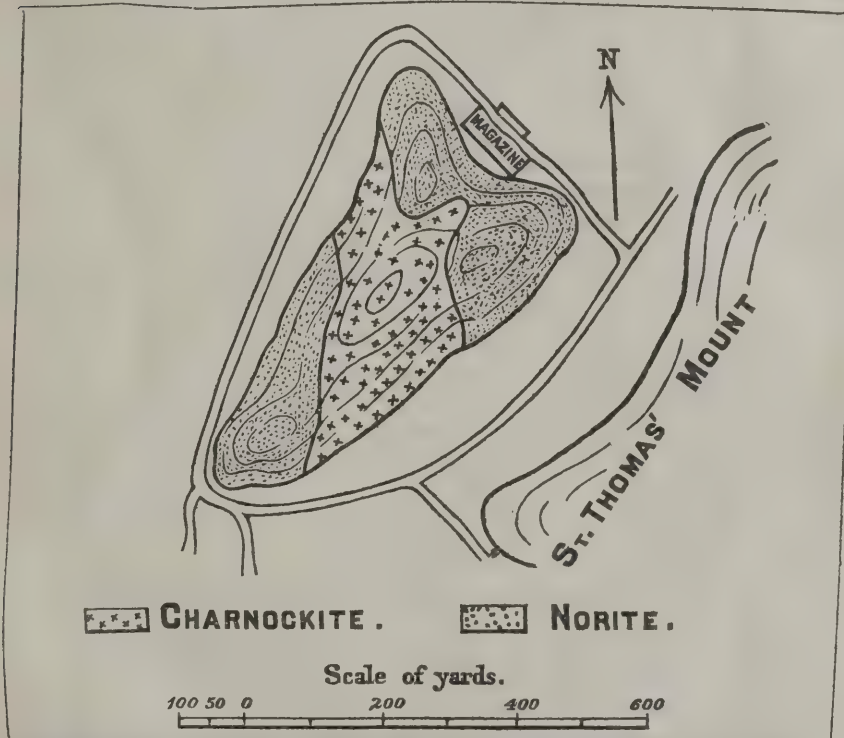
“I have prepared a memoir on the *charnockite* series of *South India* giving a detailed account of the microscopical and chemical characters of the normal as well as the altered varieties, together with an account of their leading field characters and the scenery of the areas in which they are so largely developed. The rocks which are grouped together under this name constitute the largest formation in the crystalline schists of the *Madras* Presidency, forming besides numerous small hills, the main mass of the *Shevaroy*s and *Nilgiri*s, with a portion, at least, of the *Polnis*, and the *Travancore* ghats to *Cape Comorin*. Similar rocks are known in *Burma*, *Ceylon* and again in *Madagascar*; in fact, they must have constituted the protaxis of the old pre-cretaceous continental ridge connecting *India* and *Africa*.

In the field, as well as under the microscope, these rocks present a striking individuality, which enables the worker to separate them at once from the other groups of gneisses. The one constant feature throughout all varieties is the presence of *hypersthene* amongst the mineral constituents. They vary in composition from acid types, containing 75 per cent. of silica, to

ultra-basic pure pyroxene rocks, containing only 48 per cent. of silica. The leading varieties are, in order of descending acidity :—

- (1) Charnockite, or hypersthene granite.
- (2) "Intermediate" or mixed forms.
- (3) Norites.
- (4) Pyroxenites.

The type mass selected for *charnockite* is the central portion of the hill south of the powder magazine near St. Thomas' Mount, Madras. The mass selected for the typical *norite* of this series forms the flank of the same hill. The "intermediate" varieties are typically developed in the Shevaroy hills where the rocks have an average specific gravity of 2.775, and a composition equivalent to about one part norite to three parts charnockite. The typical masses of pyroxenite form narrow dykes in the hill near Pammal village, west of the railway station of Pallavaram, near Madras. Specimens of each of these types are preserved in our Museum and will be supplied also to the Madras Museum.



Map showing Type Masses of CHARNOCKITE and NORITE, near St. Thomas' Mount, Madras.

The nearest foreign equivalents of this group of rocks are those known to the German geologists as "pyroxene-granulites," well known from the Saxon occurrences, and to the French geologists as "pyroxene gneisses" which are well developed in Brittany. The norite groups of Scandinavia are also probably the same, and from these Professor Vogt in 1893 described, as a new type, a hypersthene-granite precisely similar in composition to our charnockite, whose discovery was announced in our *Records* at the end of 1892.

Before the microscope was employed in Indian geology, the older members of the Survey had fully recognised the peculiar field characters of this group, and referred them to the younger (upper) division of the gneisses in contradistinction to the more granitoid types which were considered to be older. All recent researches tend to confirm this view, which is in agreement with the classification of similar rocks in France, Scandinavia and America.

But the older ideas concerning the origin of these rocks probably needs revision. Following Lyell, most of the old geologists considered the banding and foliation of the gneisses to be evidence of their sedimentary origin, but as precisely the same structures have now in several instances been found in undoubted eruptives, even of tertiary age, the banding and foliation structures can no longer be regarded as reliable evidence, and the origin of each group of gneisses must depend on its own local features. With regard to the charnockite series the chemical composition, mineral characters, and many of their structures are completely paralleled amongst well known igneous rocks, whilst no sedimentary rocks are known to present these characters. In addition to this, narrow dykes of these rocks have recently been found in Coorg showing the characteristic basic and chilled selvages of igneous intrusions. It is concluded, therefore, that though this group of rocks may still be retained in their old position amongst the gneisses they must be considered to be igneous rocks erupted into still older gneisses.

Mr. R. Bruce-Foote, late Superintendent in this Department, who has made a more extensive field study of the South Indian crystallines than any other geologist, agrees with this retention of the group in its old-established position amongst the upper gneisses, and also with this revision of our opinions as to the nature of its origin.

*Geology of the neighbourhood of Salem.*

The rocks examined near Salem last August form the following groups :—

- (1) Quartz-rock.
- (2) Augite-diorites (diabases) and augite-norites with micro-pegmatite.
- (3) Peridotites.
- (4) Charnockite series.
- (5) Biotite gneisses, thinly foliated "leaf-gneisses," and quartz-magnetite-hornblende schists.

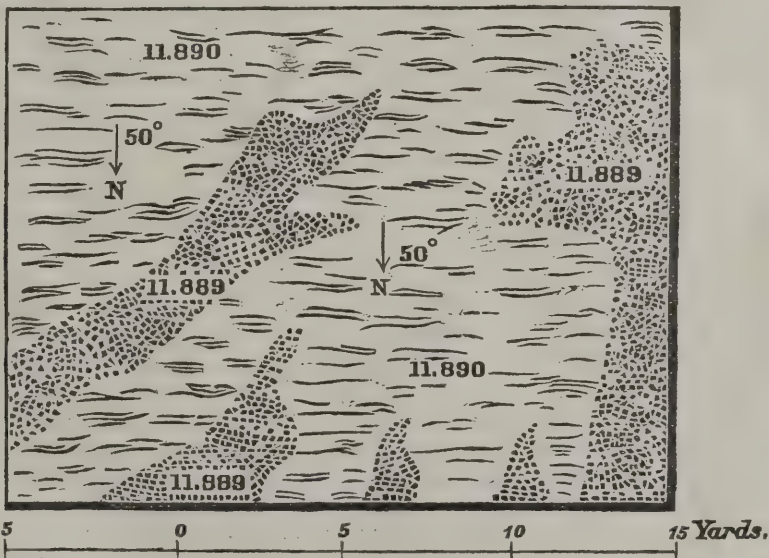
The great masses of quartz forming the "white elephant rocks" on the southern slopes of the Shevaroy were found, on microscopical examination, to contain numerous cavities filled with liquid carbonic acid, such as are

usually found in intrusive veins of quartz. This confirms Messrs. King and Foote's conclusions as to the origin of these great isolated masses of quartz (Mem., G. S. I., Vol. IV, p. 339).

The exposures of group 2 completely resemble in characters the corresponding types already described in my papers on the South Indian dykes (Records, G. S. I., Vol. XXX, p. 16 and Quart. Journ. Geol. Soc., Vol. LIII, p. 405). The "Chalk Hills" area was described by King and Foote in their memoir to accompany sheet 79 of the Indian Atlas. The rocks were found by me in 1892 to belong to the family of periotites (Records, G. S. I., Vol. XXV, p. 143), and further details concerning the magnesite were published by Mr. Middlemiss in 1896 (Records, G. S. I., Vol. XXIX, p. 31).

The charnockite series forming group 4 consist of the "intermediate" varieties, augite norites of the ordinary kind, as well as of a coarse garnetiferous form, and pyroxenites. The last two varieties form lenticular masses in, and are considered to present intrusive relations to, the members of group 5.

The Shevaroy Hills form a good typical example of a large mass (covering 100 square miles) composed almost wholly of the "intermediate" varieties of the charnockite series. Here, as usual, these rocks present the common internal features of a great igneous massif in the presentation of basic *schlieren* and of acid contemporaneous veins. The average specific gravity of 48 specimens taken from different parts of the hills is 2.775.



Plan showing tongues of unaltered CHARNOCKITE 11.889 corroding highly crushed BIOTITE-GNEISS 11.890.

In quarry,  $3\frac{1}{2}$  m. S. of Salem on the Namakal road.

(The figures indicate the numbers of the specimens in the Geological Museum, Calcutta.)

The most important member of group 5 is the biotite-gneiss, because its peculiarities are so exactly preserved in some gneiss pebbles of the Dharwar conglomerates, whose origin can thus, as far as petrological correlation permits, be determined.

Besides the evidence of the lenticular masses, the relative ages of this rock and the charnockite series are determined by a very interesting exposure south of Salem. These tongues of charnockite, protruding from the large mass forming the Jarugamalais, are seen to transgress across the foliation planes of the biotite-gneiss, and whilst the charnockite tongues imperfectly pseudo-morph the old structures of the biotite-gneiss, the former are quite fresh and unaltered, whilst the latter rock is crushed, and its constituents greatly changed. The charnockite must, therefore, have attained its present position by transgression after the consolidation, and even crushing, of the older biotite-gneiss.

The elæolite-syenite of Sivamalai in the Coimbatore district is found to include the following chief types :—

*Elæolite-syenite  
with graphite in  
Coimbatore.*

- (1) A foliated variety containing graphite and biotite—the prevalent type.
- (2) Coarse grained contemporaneous veins cutting through (1), and composed principally of elæolite and micropertite in crystals sometimes four or five inches across.
- (3) A granulitic form devoid of graphite but containing microcline and plagioclase.
- (4) A mottled variety in which hornblende has partly replaced the biotite and is accompanied by calcite.
- (5) Basic lenses composed principally of hornblende with calcite, elæolite and smaller quantities of the other ordinary constituents.

As is the case in the typical occurrences of this remarkable group of rocks, the elæolite-syenite of Sivamalai is accompanied by large masses of augite-syenite which, like the typical laurvikite of South Norway, contains olivine.

The peculiar features revealed by these groups of rocks are of very great interest in their bearing on petrological problems which have recently come into prominence: in the first place, elæolite has never been found amongst the old crystalline schists, but is always found as a constituent of undoubted eruptive rocks. At the same time graphite has always been considered to be a typical constituent of metamorphic rocks, its occurrence in which has been supposed to be proof of their sedimentary origin, whilst it is not known in unequivocal igneous rocks. But in Sivamalai these two minerals, elæolite

and graphite, are found together as evenly distributed and essential constituents of the same rock-mass. As all the other evidences, chemical composition included, point to the similarity between this rock and the known elæolite-syenites in other parts of the world, the Sivamalai mass must be considered to be of igneous origin, in which case, whilst we have to revise our ideas concerning the nature of graphite, the presence of this mineral in the elæolite-syenite adds another variety to this group, every occurrence of which presents a peculiarity of its own.

Accepting the conclusion that this elæolite-syenite agrees with all other occurrences of the rock in being of igneous origin, the peculiar features which it here presents, throw great light on many other problems in the crystalline area of South India. Some of the members, for instance, of the charnockite series (which constitutes probably the largest formation in South India) have been found to contain graphite which hitherto has appeared to be in conflict with the many evidences pointing to the igneous origin of these rocks. Another difficulty that may now be removed is the constantly granulitic structure of the lenticular masses so common in the Archæan gneisses: these lenses of elæolite-syenite present a similar granulitic structure and foliation; but in some cases the peculiar interlocking of constituents in igneous rocks has been preserved, whilst where slight deformation has occurred the branched crystals are found to be dislocated, though still preserved in groups, and presenting a true granulitic structure. The granulitic structure thus remains no longer a difficulty in the lenticular masses which in mineral characters and chemical composition completely resemble known igneous rocks.

But the most important feature in connection with this discovery of elæolite-syenite is the bearing it has on the origin of the corundum associated with it. The corundum is found in a felspar rock which invades the elæolite-syenite in the neighbourhood of Sivamalai, and is worked by the villagers at or near the junction of the two rocks. As the elæolite-syenites contain a higher percentage of alumina than any other known igneous rocks, it is natural to look to it as the source of the excess of alumina which has crystallized out near the junction as pure corundum. The observation is all the more interesting because corundum, precisely similar in crystallographic characters to that near Sivamalai, has been prepared artificially by simple fusion of the mineral elæolite.\*

All other occurrences of elæolite-syenite have been characterised by the occurrence in it and the associated rocks of minerals containing the rare elements. No exhaustive chemical investigation of the Sivamalai rocks has yet been undertaken, but it is not likely to prove an exception to the rule, and indeed two or three minerals have already been found in these rocks

\* Hautefeuille and Perry; *Bull. Soc. Min.* XIII, p. 147, 1890.

which cannot be referred to any well-known species, and therefore cannot at once be identified.

*General considerations.*—Two very interesting points arise out of our recent study of the Madras crystalline rocks :—

- (1) The remarkable abundance of the mineral pyroxene, and,
- (2) The great freshness of minerals like olivine and *elæolite* which in Europe are almost always badly decomposed, even in rocks of comparatively young geological age.

The first point is in agreement with our now well-established conclusions as to the long period of quiescence which peninsular India has enjoyed since lower palæozoic times ; for the pyroxenes are amongst the most susceptible of all minerals to dynamo-metamorphism. The second point arises naturally out of the first and indicates that, except in the immediate neighbourhood of the coast, the Madras Presidency has probably never since Cuddapah times been depressed below the sea-level, but on the other hand has undergone uninterrupted denudation, with the result that relatively deep portions of the crust have been brought to the surface. It is this exposure of the very deep-seated rocks by a continual denudation probably unequalled, except in the remarkable protaxis of Canada, that has revealed to us a set of rocks in Madras quite unfamiliar to our European experience ; amongst these the quartz-barytes rock discovered during the past year in Salem and the *elæolite*-syenite, now described from Coimbatore, are unique types.

The following summary of field-work in Coorg has been sent in by Mr. Holland who was in charge of the survey : field-work commenced on the 1st December last, and has continued without interruption up to the present date. Previous to this survey of Coorg no information of any kind concerning its geology was available.

COORG.  
Mr. T. H. Holland and  
Dr. T. L. Walker.

*I.—Petrography.*—Except the alluvium and laterite, which cover considerable areas, no unaltered aqueous rocks have been found. Of the crystalline rocks the following groups have been mapped and their leading features determined :—

- (1) Biotite-gneisses.
  - (2) The Mercara group.
  - (3) The charnockite series.
  - (4) The central granite-group.
  - (5) The norite "stock" of Watekolli.
  - (6) Dharwars.
  - (7) Basic and ultra-basic rocks intrusive since the close of the N.W.-S.E. system of foliation.
- (1) The *biotite-gneisses* are similar in character to those generally considered to represent the older (lower) division of the gneisses and require no special mention.

- (2) Under the name *Mercara group* I propose to distinguish a belt of thinly foliated gneisses and schists forming the Mercara plateau, and stretching in a N.W. to S.E. direction along the centre of Coorg. The most remarkable feature in connection with this group is the enormous abundance of the mineral kyanite, which is usually comparatively rare. Sometimes there are bands of almost pure kyanite, whilst at other times it is associated with quartz, biotite, graphite, purple garnet and rutile. Towards the south-east end of the belt occur exposures of a very handsome variety, composed of deep-blue kyanite, in crystals two or three inches long, with chrome-green euphyllite and a small quantity of quartz. With the kyanite-schists which form the predominant type, there occur garnetiferous biotite-gneisses and quartzites in subordinate quantity. Bands and lenticles of green amphibolite and veins of pegmatite are very common. The latter sometimes contain large mica crystals. Although the characters of this group are in general agreement with those which usually mark the younger (upper) division of the gneisses, the great abundance of kyanite distinguishes it from any other formation so far described in India. It is interesting to note that the distribution of the Mercara group is roughly coincident with the most productive belt of coffee plantations.
- (3) The *charnockite series* flank both sides of the Mercara group and present the normal characters displayed elsewhere in the south of India. Several interesting exposures have, however, been found which throw great light on the origin of this group of rocks. On the N.E. side of Coorg the large masses are fringed by numerous bands of the intermediate and basic varieties, running like dykes through the surrounding biotite-gneiss, and generally, but not always, parallel to the foliation of the latter. Careful examination of some of these show that they are more compact and basic at the selveges than in the centre of the bands, and microscopic examination shows that the marginal portions are more hornblendic, a feature which characterises the border facies of similar pyroxenic intrusives elsewhere. At the same time, these dykes, as they must now be recognised to be, contain the essential and usual constituents of the charnockite series, presenting their characteristic habits, and, like the larger masses, often contain garnets. It is interesting to find that these marginal portions of the dykes agree with the basic, fine-grained secretions of the larger masses in being more hornblendic than the average type, both

being the products of early consolidation in their respective intrusions. Taken into consideration with the phenomena noticed last year near Salem, where tongues of unaltered charnockite were found corroding a highly crushed gneiss, the dykes recently found in Coorg may be regarded as conclusive evidence in favour of the intrusive nature of the charnockite series. Though these recent observations necessitate a change in our views concerning the *origin* of these rocks, they tend only to confirm their *position* in the classification of the Archæan rocks adopted in the earlier days of the Geological Survey and recently repeated by Mr. Foote in his memoir on Bellary.

- (4) A large stock of *porphyritic biotite-granite* crops out in the centre of the belt of Mercara schists, and further exposures of the same rock have been found to the south-east, near one of which was discovered a felsitic form with bi-pyramidal phenocrysts of quartz. The granite must have consolidated before the completion of the N.W.-S.E. system of folding was complete, and consequently it shows the characteristic strain-slip cleavage with slickensides lubricated by crushed mica—the result of crushing after consolidation. Except at some points on its western border, where it is limited by a (probably faulted) junction with the Mercara group, there are practically no exposures sufficiently clear to settle the relations of the granite to the other rocks. Near its margin, however, masses of sillimanite-gneiss have been found in the granite and probably represent a contact product due to alteration of the kyanite-schist, which would be a perfectly normal occurrence. So far as it goes, then, this evidence points to the granite being younger than the Mercara group.
- (5) The large mass of *norite* at Watekolli forms a distinct addition to Indian petrology. The crystals, sometimes an inch or two long, of pink labradorite and schillerized pyroxene make a very handsome rock. Besides the coarse-grained forms, there is a compact, granulitic, marginal facies, containing hornblende, which is extremely difficult to distinguish from the basic forms of the charnockite series, the similarity being accentuated by local foliation. This rock must have been erupted near or after the close of the earth-movements which foliated the rocks of the western Ghâts.
- (6) Hornblende-schists and quartz-hematite schists similar to those of the *Dharwar System* form two very small strips in the extreme north of Coorg. They are cut through by both systems of basic

dykes, and are foliated as well as banded with apparent conformity to the biotite-gneiss.

- (7) Next in order come the *basic and ultra-basic intrusives*, which show no foliation and sometimes form dykes at wide angles to the youngest fold-axis. The *ultra-basic* types include, besides some fine masses of pyroxenite, exposures of dunite (olivine-rock) and picrite, the former being decomposed after the fashion of the well-known occurrence of the "Chalk Hills," Salem, with the formation of magnesite and serpentine. The *basic* dykes form two principal groups: one group shows considerable progress towards the formation of epidiorites by granulation of the felspars and granular amphibolization of the pyroxenes. These form a N.S. series of prominent dykes in the N.E. corner of Coorg and represent an old eruption, probably of the Dharwar age. The others are remarkably fresh rocks, composed of augite and felspar in the south, but containing also olivine in the northern occurrences. One fine dyke of this group runs in a W.S.W.-E.N.E. direction completely across Coorg, approximately agreeing with the boundary line of the low-lying taluk of Kiggatnád, and almost, though not completely, separating the basin of the Cauvery from that of the Lakshmantirtha. These large dykes of very fresh basic rock are probably the underground representatives of the Deccan trap.

*II.—Structural features.*—The general direction of the foliation of the younger schists throughout Coorg is N.W.-S.E. or N.N.W.-S.S.E., that is, parallel to the direction of the western Gháts and of the Malabar coast-line. Our observations thus fall in with the evidence obtained by Mr. Foote as to the parallel folding of the Dharwar strips in western Mysore, and shows that, whilst the present contours may have been determined by the uninterrupted, geologically-long course of denudation, the leading features are, as in young mountain ranges, still coincident with the final system of folds. As one result of this N.N.W.-S.S.E. folding, the rocks in Coorg frequently show dislocations in the E.N.E.-W.S.W. direction which have determined the position of some of the younger dyke-rocks. In some cases the unequal folding on opposite sides of these transverse dislocations has resulted in horizontal displacement of the beds. The general dip of the foliation planes is towards the S.W.; it will be interesting now to find from the South Canara side whether the much steeper western face of the Gháts is the result of an opposed dip with the production of a synclinal fold and scarp face, or the mere effect of exposure to the unchecked force of the monsoon.

*III.—Economic Minerals.*—Graphite has frequently been found disseminated through the rocks, but so far has not been observed in any concentrated form.

The discovery of pegmatites amongst the Mercara group led to a careful search being instituted for mica, with the result that in five or six localities sheets, well beyond the marketable size, have been obtained. The largest were obtained on Elk Hill, where from immediately under the soil, sheets free from warping and measuring some 30 inches across, were removed from the outcrop of the vein. All samples show a high degree of elasticity and good colour, but much of the material will have its value depreciated by ferruginous inclusions between the cleavage-planes, whilst some of the mica is badly warped. As to how far these defects reduce the value is now being ascertained in the London market.<sup>1</sup> It is extremely unlikely that the best veins have been the first to be "struck" in an area so completely soil-covered but enough has been shown to prove that the mica-bearing pegmatites extend over a wide area, and will probably be a source of sensible profit if worked with discretion.

The occurrence of the younger division of the gneisses at once suggested a search for limestone, which is specially in demand for the coffee plantations, but so far no trace of the rock has been observed.

Linga Raja who built the palace at Mercara in 1812 has set the example of utilizing the diabase dykes for ornamental architecture; but the large slabs which he secured could only have been obtained from such a close jointed rock by an enormous expenditure of labour. This rock is still much used for mill stones and mortars. There is a mass of coarse potstone to the south-east of Mercara, which might easily be turned into vessels, but has not apparently been worked.

### 3. Bombay Presidency.

The country north and north-east of Ahmadabad in the Gujarát province, to the Mahakántha States was reconnoitred during last field-season by Lala Kishen Singh with the special object of defining the alluvial areas from the older rocks, which form the south and south-western extensions of the Aravalli ranges. No detailed report is at present available, but it may be expected that the results of the reconnaissance will not be of a very startling character, as is shown by the monthly diaries of work sent in already.

### 4. Western Rajputana and South-Eastern Marwar.

A great deal of geological survey work was accomplished in former years in Western Rajputana; Messrs. W. T. Blanford and Hackett have already described much of the country

<sup>1</sup> Since this report was written, an answer has been received from London, which shows that the defects mentioned do not materially lessen the marketable value of the mica, which will fetch very good prices at home.

around Jodhpur, but many of the more or less isolated hills which stand out of the sand-covered plain of Rajputana were geological blanks on our maps.

Season 1896 to 1897. Mr. LaTouche was engaged during the seasons 1896 to 1897 on a detailed survey of that country, and during that season accomplished to fill in the geology between Jodhpur and the higher hills south of the Luni river, on which country he has sent in an interesting progress report, fully illustrated. I quote his summary :—

By far the greatest portion of the country with which this report deals is covered with blown sand and alluvium, forming broad stretches of more or less level plain, diversified by low sand-hills, and when the seasons are favorable, bearing excellent crops, principally of millet. At intervals in this plain isolated rocky hills rise abruptly from it, looking as though they were the peaks and ridges of some great mountain range, the lower slopes of which have been smothered in sand. The largest of these hills are found in the Siwana district to the south of the Luni river, where one mass, called the Saoru range on the map, reaches an altitude of over 3,000 feet above the sea, and another rises to between two and three thousand. All the rocks found in this region with the exception of a small area in the extreme north-east, in the immediate neighbourhood of Jodhpur City, are of various crystalline types, including ancient lavas, rhyolites and felsites with intercalated bands of tuff ashes and breccias, to which the name of 'Malani series' was given by Mr. Blanford, intrusive dykes of diorite, and intrusive granites probably belonging to two distinct periods, one containing much hornblende and no visible mica, the other with both hornblende and mica in microscopic crystals.

In spite of the great age of the rocks belonging to this series, and the great alteration which they have undergone, there is clear evidence, that when originally formed they were true volcanic ejectamenta spread out over the surface of the country and probably subærial. All the well-known characteristics of glassy rocks can be observed in the lavas. Some of the flows show beautifully developed flow structure and may be called rhyolites. In some of them the original glassy texture has hardly undergone any alteration, so that a thin slice remains almost dark under the microscope between crossed nicols. Sphærolitic and perlitic structures occur in other cases, and some of the flows are vesicular. Moreover, in many places the lava flows are interstratified with tuffs, ash beds and breccias.

That the volcanoes were subærial is proved by the fact that beds of shingle composed to a large extent of the waterworn debris of the volcanoes themselves are found in several places interstratified with the lava flows. These

Conglomerates asso-  
ciated with lava flows.

could not have been formed in deep water, since the pebbles are sometimes of considerable size, but were washed down by streams flowing over the surface of the lava beds, and they show that denudation of the surface was going on during the period of volcanic activity.

No undoubted indications of the position of any of the vents through which the lavas were poured out have yet been found.

Possible vent at Nagona. This is not to be wondered at when we consider how large a portion of the region is concealed by sand. At Nagona, however, about 33 miles to west-south-west of Jodhpur, the existence of a vent is conjectured from the presence of a mass of rhyolite felsite, in which the lines of flow are vertical, causing the rock to split into thin plates resembling shales. The fissile structure may have been imparted to the rock by pressure from the sides of a fissure through which it was erupted. The vent, if it was one, appears to have been in the form of an elongated fissure, the longer axis of which runs from south-east to north-west. On either side of this locality the lava flows were observed to dip away from it in opposite directions, and there may have been a true volcanic vent here, but it seems more likely from the absence of any general arrangement of the lava flows in a conical form, that the eruptions were of the fissure type.

The exact geological age of the Malani series is still undetermined, because they have as yet been nowhere found in contact with rocks whose exact horizon is known. They are certainly much older than the sandstones which rest upon them at Jodhpur, which are conjectured to belong to the upper Vindhyan period, for a conglomerate largely made up of rolled pebbles and boulders of the Malani lavas, mingled with other crystalline rocks, is found at the base of the sandstones. So far they have not been found in contact with any of the rocks of the Aravalli series, and their relation with the latter are still uncertain.

The lava flows, at some time since their eruption, and after the development in them of joint planes, were invaded by dykes of a basic rock, containing plagioclase felspar and hornblende, which broke through them along the lines of jointing, the majority running due north and south. The dykes are usually much decomposed and are more easily weathered than the felsites, so that they lie in trenches between vertical walls of the latter. They are most common among the hills to the south of the Luni, especially in the range of hills about 6 miles south-west of Belotra, and only one was found to the north of the river, near the villages of Samdari.

Subsequent to the intrusion of the diorite dykes, huge bosses of granite, very coarse in texture and composed of quartz orthoclase felspar and hornblende, were forced in among the felsites, probably along the axes of the folds into which these rocks had been thrown. Wherever the two rocks are found in contact, the granite

throws off ramifying and interlacing veins among the felsites, and the latter, with the associated beds of tuff, are sometimes altered at the point of contact. The granite forms the greater part of the Suora range, the largest continuous mass of rock in the country. The distributions of the granite bosses is somewhat peculiar. They lie along a fairly continuous ring, interrupted for any considerable distance only on its north-west side, measuring roughly 19 miles in diameter from east to west, and 16 miles from north to south. Towards the centre of this ring the granite does not appear anywhere at the surface. The arrangement suggests that the lines of weakness along which the granite was protruded was circular in plan, and may have had some connection with the roots of a volcano. There is nothing however in the disposition of the felsite flows and ash-beds to bear out this suggestion, but they have been disturbed by folding, as is shown by the present inclination of the pebble beds interstratified with, which must have been laid down on a more or less horizontal surface, so that their original arrangement has been marked by subsequent earth movements. Although the granite has in some cases pushed aside the lava flows, in many other instances it has evidently invaded and absorbed them, since the flows can be seen to dip towards or strike against the steep sides of the granite bosses.

That the hornblende granite is younger than the diorite dykes is proved by cases in which veins from the granite penetrate the dykes, and also by the fact that the diorite is never found intrusive in the granite, though it sometimes runs up into contact with the edges of the latter.

*Summary of Observations, Season 1897-98.*—The ground surveyed and mapped this season comprises an area of about 2,000 square miles, lying to the south and south-east of that dealt with in my report for last year. The general features of the country are very similar, the greater part of it being covered with blown sand and alluvium, through which solid rocks protrude in patches of greater or less extent, forming rugged hills and ridges isolated from each other—a structure which makes it very difficult, and often impossible to trace the boundaries of the various formations. A portion of the ground had already been surveyed and mapped by Mr. Hacket, but in the only published account of his observations,<sup>1</sup> he gives very few details of the relations of the rocks to each other.

The principal object was to discover if possible the relations between the Malani volcanic series and the Aravalli rocks. Mr. Hacket mentions one locality in which the Malani rocks rest upon rocks of a different type,<sup>2</sup> and two in which they are seen very close to each other. The first mentioned

<sup>1</sup> Records, G. S. I., Vol. XIV, Pt. 4.

<sup>2</sup> *Idem*, p. 302.

locality is about 8 miles to the north of Chanod, and here the evidences of unconformity between the two formations seem to be clear, for not only is the strike and dip discordant, but in places a bed of coarse conglomerate containing rolled fragments of schist and slate derived from the lower beds is intercalated between them. Mr. Hacket was in doubt as to whether the slates and schists here were Aravallis, but there seems to be no difference between them and some slaty beds which occur in close proximity to a ridge of Malanis near Chotila, about 8 miles further north, which Mr. Hacket considered to be undoubted Aravallis. They are certainly in a much less metamorphosed condition than the schists found in the plain to the west, but it may be suspected that a fault of considerable throw must occur along the eastern edge of the area occupied by the Malani rocks, running in a general north-east to south-west direction. No outliers of the Malanis occur, so far as known to the east of this line.

Excluding the Aravalli schists, slates and quartzites, the whole of the rocks in this area were mapped by Mr. Hacket as gneiss, but it was found that although some of them may be described under that name the greater portion consists of true granite and that this can be referred both on lithological and stratigraphical grounds, to two distinct periods. The older granite which is typically developed in the neighbourhood of Erinpura, is an exceedingly coarse-grained rock, the crystals of felspar reaching a length of 3 inches or more. It is intrusive in the Aravalli schists, but was intruded prior to the movements which resulted in the folding of those rocks, so that it frequently exhibits a well developed gneissose structure, especially near the juncture with the schists, the felspar crystals being drawn out into 'eyes' surrounded with mica. The veins which it sometimes throws off into the schists have also been contorted and crushed. The newer granite, on the other hand, is not so coarse-grained, generally contains red felspar and a considerable proportion of hornblende as well as mica, and never exhibits any trace of a foliated structure. It forms a series of isolated hills and bosses, extending from near Jodhpur along the eastern edge of the Malani area to the town of Jalor, about 70 miles south-south-west of Jodhpur and 30 miles west-north-west of Erinpura. It is intrusive in the Aravalli schists, and also in the Malani volcanic rocks, wherever it occurs in contact with them. The form of these granite bosses, their distribution, and their relations with the lavas, all suggest that they may occupy the vents from which the latter were poured out.

All these rocks, including the Aravallis, are traversed by a system of dykes of basic rock, diorite, varying in direction from about north-north-west to west-north-west. They occasionally reach large dimensions, as in the hill at Jalor, where they break through the red granite, and in two cases at least are quite 200 feet wide. The rock of which they are composed usually

weathers more readily than the surrounding rocks, so that narrow chasms with vertical walls on either side are formed, and they are frequently found on the crests of narrow passes through the hills.

The two granites mentioned above are distinguished from the hornblendic granite described in last year's report as intrusive in the Malani series further west, in the district of Siwana, by the fact that the last contains no visible mica, and moreover has been intruded into the Volcanic rocks subsequently to the intrusion of the diorite dykes, which are never found piercing it.

For the sake of reference it is proposed to adopt the following names for these granites provisionally, commencing with the oldest :—

1. Erinpura Granite.—Forms a large spread to the north and east of the station of Erinpura, and extends beyond the limits of the area surveyed. Typically a very coarse-grained granite, with large crystals of white or grey felspar up to 3 inches in length, quartz and mica. Intruded into the Aravalli schists prior to their disturbance and folding, and near the junction frequently assumes a foliated structure.
2. Jalor Granite.—Forms a series of bosses extending from near Jodhpur along the eastern edge of the Malani area to Jalor and probably further south into Sirohi. The large hills in the neighbourhood of Jalor are mainly formed of it. Generally a rather coarse-grained granite containing red or flesh coloured felspar, quartz, mica, and hornblende. Intrusive in the Aravalli rocks and in some portion of the Malani volcanic rocks, and traversed by diorite dykes.
3. Siwana Granite.—Forms the greater part of the high range immediately to the south of Siwana, and occurs in many other hills in this district. Usually a rather coarse-grained granite, containing white or red felspar, quartz and hornblende, but no mica. Intrusive into the Malani volcanic series subsequent to the intrusion into it of dykes of diorite.

All these again are distinct from the granite which occurs in dykes and veins among the Aravalli rocks of the main range to the east,<sup>1</sup> and which is characterised by the presence of tourmaline. This type of granite has not been met with west of the main range.

The rocks of the Malani Volcanic Series occurring in the area surveyed this season are generally similar to those described in Mr. LaTouche's progress report for last year, consisting of porphyritic devitrified rhyolites with occasional bands of ash, tuff and pebble beds.

<sup>1</sup> Hacket, Records, G. S. I., Vol. XIV, Pt. 4, p. 232.

All the rocks met with are of either igneous or metamorphic origin, and no trace of any fossiliferous rock has yet been discovered in this region. Consequently it is impossible to refer the formations met with to any definite geological horizon. All that can be said is that they are older than the sandstones which rest unconformably upon the Malanis at Jodhpur, which probably belong to the Vindhyan period.

Some progress has been made with a microscopic examination of the characters of the Malani lavas and allied rocks. So far the microscopic study entirely confirms Mr. Blanford's conjecture, arrived at from an examination of the rocks in the field,<sup>1</sup> that they were originally glassy lavas, which were poured out at the surface.

### 5. Central India.

The work in South Rewah, which had been carried on under Mr. South Rewah. Oldham's superintendence during the previous season, E. Vredenburg. was continued single handed by Mr. Vredenburg during 1896 to 1897 and may be practically considered as finished for the time. The progress reports sent are in the form of more or less disjointed descriptions of the different areas passed over and with the series of specimens collected will greatly assist the compilation of the final report on the Geology of Rewah, which will have to be written by Mr. Oldham. The results of the season's work are more or less of local interest only.

At the beginning of the last cold season Mr. Vredenburg was posted to Bhopal. \* Bhopal and Gwalior, and he has not yet returned to head-quarters.

His reports as follows:

The region so far examined in Bhopal lies between the parallels  $22^{\circ} 30'$  and  $23^{\circ} 30'$  of latitude, and  $77^{\circ} 30'$  and  $78^{\circ} 30'$  of longitude. The rocks exposed throughout this area belong to two of the principal geological systems of India, the Vindhyan and the basalt flows of the Deccan and Malwa trap, with their associated intertrappeans. Along the southern portion of the district surveyed, both series are much concealed beneath the post-tertiary Narbada alluvium.

The basalt occurs in more or less discontinuous patches, there being seldom any considerable interval entirely free from that rock; in many cases there remains but a sheet of small thickness occupying the floor of the Vindhyan valleys, while in other instances denudation has not proceeded so far and there are several hundred feet of accumulated lava flows rising into a plateau above which the highest portions of the ancient Vindhyan scarps form small inliers.

<sup>1</sup> Records, G. S. I., Vol. X, Pt. I, p. 17.

It is evident, from the disposition of the geological boundaries, that the modern topography of the Vindhyan reproduces in its main lines the pre-trappean features, the ancient land surface being once more brought to light owing to the comparatively rapid disintegration of the basic volcanic rocks. Remains of a pre-trappean soil and talus exist in several localities, sometimes more or less altered by the contact of the molten lava "intertrappean" beds both calcareous and siliceous are met with, sometimes limited on one side by the Vindhyan slopes whose drainage interrupted by a lava flow gave rise to the lakes in which these rocks were laid down.

The proximity of the great masses of lava has produced no appreciable alteration in the Vindhyan. The most careful search has failed to detect any intrusive dykes or other signs of the immediate neighbourhood of volcanic centres; these must have been situated along some other region, probably further south.

The strata have suffered no disturbance since the basalts were erupted, for these rest horizontally upon the folded Vindhyan and are quite unaffected by a considerable fault which runs through the older rocks in the neighbourhood of Bari (Lat.  $23^{\circ} 2'$ , Long.  $78^{\circ} 7'$ ).

Throughout the districts examined, the "black soil" forming the superficial covering over a large portion of the country, is strictly confined to the volcanic outcrops, beyond which it never extends but for very short distances. "Laterite" is found capping some of the higher summits of the basalt plateau.

The Vindhyan rocks exposed belong all to the upper series; although the lowermost member of this division, the lower Kaimur is seen in several localities, yet the underlying rock is in all cases concealed by basalt or alluvium, so that nothing can be said regarding the existence or otherwise of the lower Vindhyan.

The examination of the upper Vindhyan has resulted in thoroughly confirming Mr. Mallet's prevision as to the presence of the Kaimur stage (Mem. Vol. VII, pp. 54, 55, 67, 77, 96). Only a fraction of this area had been previously examined in a cursory manner, and on that occasion the shale bands which constitute the main clue to the interpretation of these unfossiliferous rocks remained generally undetected, concealed as they are in many instances under newer deposits, or else entirely hidden for great distances by the talus of debris from the overlying sandstones. Hence it was concluded that the entire series consisted of one uninterrupted mass of sandstone which it was difficult to correlate with the divisions previously established elsewhere. During the present season, owing largely to the admirably accurate topography of the maps now available, it has been possible to recognise and follow successfully no less than four distinct shale bands, and judging from previously published descriptions there seems to be every

reason for identifying them with the various shales recognised in the Vindhyan regions surveyed to the north and east.

The divisions made out are, in ascending order, as follows:—

- (1) Shales, mainly arenaceous and micaceous; a thickness of 200 ft. is seen in places, but the base is nowhere exposed.
- (2) Conglomerate with pebbles frequently two or three inches in diameter, consisting of vein quartz and various Bijawar rocks.
- (3) Fine grained, very thick-bedded sandstone, an excellent building material very similar to the Chunar sandstone, except that it is uniformly of a dark red colour. The uppermost beds of this division are flaggy. The aggregate thickness of (2) and (3) is about 400 ft.
- (4) Compact sandstone, the upper part extremely thick-bedded and forming precipitous cliffs. Thickness 500 ft.
- (5) Shales averaging 200 ft. in thickness, resting with a sharp junction on (4) but passing gradually upwards into.
- (6) Alternately thick and thin-bedded sandstones forming a succession of scarps which vary greatly in number and size; at the base of this division there exists a remarkably constant band of false bedded flags, largely quarried all along their outcrop. Thickness 400 to 600 ft.
- (7) Shales which increase considerably in thickness from east to west. It is this band which is exposed at Ganurgarh fort, this name having been applied to designate one of the Bhandar sub-divisions. At the above locality they contain an important limestone which is however only local. Eight miles east of Ganurgarh, the limestone is represented merely by strings of calcite running through the shales, and still further east, the shales themselves thin out almost entirely. At Ganurgarh the shales with the included limestone are over 500 ft. thick, twenty miles east their thickness is reduced to 200 ft., and in the neighbourhood of Bari, about forty-five miles from Ganurgarh, there are not more than 40 ft. of shale largely interbedded with sandstone, while in one locality near Mahilpur (Lat.  $23^{\circ} 16'$ , Long.  $78^{\circ} 5'$ ) the band seems to be altogether extinct.
- (8) Sandstone, 800 ft. thick. The bedding and petrology vary greatly, the beds generally becoming finer-grained and thinner-bedded in proportion as the thickness of the underlying shales increases. Where the sub-stage (7) attains its maximum dimensions, there is even a subordinate shale band, 60 ft. thick, situated some 120 ft. above the base of (8).

(9) Shales, 200 to 300 ft., argillaceous, brittle, very thin-bedded.

(10) Dark red sandstones very thick-bedded, generally containing fine building stones.

The divisions (1) to (4) agree entirely in their petrology and stratigraphy with the Kaimur rocks of Bundelkhand and of the Son valley; it may be safely concluded that (1) represents the lower Kaimur shales, (2) the Kaimur conglomerate, (3) and (4) the upper Kaimur. The two next divisions (5) and (6) evidently belong to the Rewa stage, and (9) and (10) to the Bhandar. The only remaining uncertainty is whether the sandstone (8) should be regarded as the upper Rewa or lower Bhandar.

The shales (7) which previous observers examined at Ganurgarh were regarded, principally perhaps on the strength of the limestone, as representing the lower Bhandar. But considering their irregular development, and the thickness of the sandstone (8) which is out of all proportion with any recorded observations of the comparatively insignificant lower Bhandar sandstone, the simplest explanation would appear to be that (7) represents the Jhiri shales, and (8) the upper Rewa sandstone. It is hoped that this point will be completely settled when the survey is extended as far as the regions previously examined in detail.

The upper Vindhya's are folded along two axes of disturbance, one of them running East-North-East to West-South-West being the continuation of the features developed along the Son and upper Narbada valleys, while the other is nearly at right angles, that is along a North-North-West to South-South-East direction. The combination of these two systems of folds gives rise to outliers of the Bhandar stage, and inliers of the rocks underlying the upper Vindhya's, the latter however remaining concealed by the overflowing basalt, so that their nature cannot be ascertained,

## 6. Central Provinces, Mandla district.

A large portion of the Central Provinces remains practically unsurveyed,

and although several patches of it have been described at different times, much work remains still to be done. Mr. P. N. BOSE, who was working in the Raipur district before he went on two years' furlough in 1895, was, after rejoining his appointment, sent to the Mandla district north-west of the area already surveyed by him, and has sent in a short progress report, which illustrates the extremely simple structure of that part of the country. Mr. Bose accounts for the limited extent of area surveyed (about 700 square miles) by urging special difficulties

owing to the dense character of the vegetation and unhealthiness of the country. I quote the following from his report:

The area examined lies in the south-eastern portion of the district of *Work done during the* Mandla. It comprises the upper portion of the valleys *season 1897 to 1898.* of the Sulkum, the Halon and the Phen which are affluents of larger rivers flowing into the Narbada. The valleys run in directions roughly transverse to the strike of the older rocks, and are separated from each other by hills and uplands formed of the Deccan trap. The general level of the country rises from about 1,600 feet above the sea level in the Sulkum valley to about 2,300 feet in the Phen valley. The higher hills rise from 500 to 900 feet above that level.

The rocks met with in ascending order are:—

1. The metamorphic rocks.
2. The sub-metamorphic rocks.
3. The lametas.
4. The Deccan trap.
5. Lateritic rocks.

From the above descriptions it will be seen that there are, in the area examined, three different types of gneiss—(1) massive gneiss in which no bedding is discernible, and which, so far as seen hitherto, is not accompanied by any schists; (2) massive bedded, coarse-grained, hard gneiss associated with highly micaceous gneiss and schists; (3) rather thin-bedded, fine-grained, soft, highly quartzose gneissic or sub-gneissic rock, associated with sub-schistose quartzite and micaceous schist. It is likely that these three types belong to three different ages, the first being the oldest and the last the youngest. The evidence for their separation, however, is not as yet very satisfactory and certainly not conclusive. The third, and presumably the youngest form of gneissic rock mentioned above has a somewhat sub-metamorphic look about it which is emphasized in the immediate vicinity of Motinala by a low dip, not amounting to more than 20°. Moreover, the rock sequence in the Phen section presents no stratigraphical break—at least none that I could discern—between it and rocks of an unquestionably transitional appearance. The question then presents itself—whether the fine-grained quartzose gneissic rock and the phyllites are of the same age? The Sulkum section at Karibah, which shows transitional passage between the phyllites and the gneiss, at least does not show any visible stratigraphic discontinuity between them, would appear to favour an answer in the affirmative. The two sets of rocks may, however, be separated by assuming a fault between them.

These rocks are very widespread. Lithologically, they vary between sandstones, which are sometimes pebbly, and siliceous limestones. They rest quite flat upon the denuded

1 and 2. The metamorphic and sub-metamorphic rocks.  
*Summary and general remarks.*

upturned edges of the older rocks, and form a narrow usually interrupted fringe between them and the Deccan trap. Their thickness is very small, not exceeding 30 feet or so; and at places there is just a skin of them.

The Deccan trap rests upon the denuded surface of the older rocks and forms all the higher hills and uplands of the area examined.

4. The Deccan trap.

It is noteworthy that before the Deccan trap flowed on to their surface, the sub-metamorphic and the metamorphic rocks had been denuded away so as to form a slope pretty nearly in the same direction as the present slope of the area, *viz.*, from south to north. For, while in the upper parts of the Phen and the Holon valleys, the older rocks are exposed at a level of about 2,000 feet, in the vicinity of Ghugri even at about 1,600 feet, the ground is covered by the Deccan trap.

Lateritic rocks have been met with in small patches in the Phen and the Holon valleys. Economically, they are important as yielding, at places, iron-ore of good quality. Lateritic ore picked up from the bed of a stream near Lalpura in the Phen valley affords means for the maintenance of a sort of intermittent struggle for existence to one primitive furnace. This is the only furnace which I have found within my ground. I have, however, heard of others in the Deccan trap area north-east of it.

5. Laterite.

## 7. Sambalpur district and adjoining country.

During last cold weather season, Mr. Smith was engaged in surveying parts of the Sambalpur district, Sarangarh and Phuljhar with small portions of Bilaspur, Borasamar and Sonpur. The area had been traversed in former years by Mr. V. Ball and others but no connected survey of it had been made, although suspected to contain valuable ore localities, which are probably altogether mythical. Mr. Smith has now sent in a short summary of the results of his survey which is given in the following :—

Mr. F. H. SMITH.

The greater part of the Sambalpur and Sonpur districts is occupied by a broad plain of gneiss, with low scattered hills of the same and intrusive rocks. The gneiss is usually syenitic, its chief constituents being white felspar and hornblende. It is frequently coarse-grained and much crushed with lenticular crystals of felspar surrounded by a crushed mass of dark fine-grained hornblendic material. The foliation, which is rare to the westward, but much more developed towards the eastern part of the area, is frequently horizontal or dipping gently; when there is a distinct dip, the general direction of strike varies from N, and S. to N. E. and N. W:

Crystalline rocks.

Dykes of dark green, fine and medium-grained diabasic trap are common, with the same general direction as the foliation of the gneiss. And one bold hill—Rossarn—of extremely massive coarse-grained intrusive gabbro or diorite stands up from the gneiss plain.

Siliceous bands and veins also occur in the gneiss. The former are generally of greenish quartz and quartz-mica-schists, but these pass into brecciated and schistose quartzite with occasional bands of jasper, and are in some cases evidently bands of sedimentary rock which have been folded into the gneiss.

West of the Sambalpur plain several patches of massive gneiss occur amongst the sedimentary rocks; they may have formed low hills and islands at the time of the sedimentary deposition.

To the extreme west of the area in the Bilaspur hills there is evidence of great intrusive disturbance. Massive trap-dykes form most of the hills, and strongly foliated chloritic schists with occasional layers of conglomerate, appear to represent metamorphosed sedimentary beds amongst them. Practically the whole of the hill country is composed of sedimentary rocks resting on the surface of the gneiss.

*Sedimentary rocks.  
Older series.*

The hills are scarped along their southern and eastern edges, where the beds end off abruptly, overlooking the great gneissic plain. From this they dip away gently westwards and northwards and are overlaid by younger beds, the uppermost of which are found in the Mahanadi valley, which bounds the area to the north.

The hills themselves comprising the Barapahars in Sambalpur, and the Sarangarh and Phuljhar hills are entirely composed of a great series of alternate quartzites and shales, which attains a thickness of over 6,000 feet. The quartzites pass locally into sandstones, grits and conglomerates while the shales are in some cases siliceous slates.

This series is overlaid with slight but distinct unconformity, by another, mainly composed of purple shales, calcareous, siliceous or sandy, and limestones, which forms a flat trough of rocks, some 2,000 feet in thickness along the Mahanadi valley. Both series appear to be totally unfossiliferous, as far as I have been able to discover.

*Younger series.*

Mr. Ball, who made a rapid traverse over an enormous extent of this country, has referred the whole of these rocks to the Vindhyan system, in his paper on the "Geology of the Mahanadi Basin." But on closer examination, the superposition of a well-defined series of limestones and purple shales over another series, entirely composed of quartzites and shaley slates, points strongly to their much closer connection with the Karnuls and Cuddapahs, and as such I shall regard them.

The best developed section of the lower "Cuddapah" series is found in the Barapahar hills, where the following beds are seen, given in descending order, with their maximum thicknesses :—

1. White granular quartzite . . . . .	200 feet.
2. Pink and buff shaley limestone and shales . . . . .	900 "
3. White and pink coarse granular quartzite . . . . .	400 "
4. Grey and yellow siliceous shales . . . . .	600 "
5. Compact grey and purplish fine quartzite . . . . .	400 "
6. Grey and pinkish laminated shales . . . . .	1,200 "
7. Massive and fine bedded compact quartzite with thin partings of grey shale . . . . .	2,000 "
8. Purple and yellow slaty shales . . . . .	400 "
9. Porcellanic shales and green felspathic grit with conglomerate bands . . . . .	400 "
	<hr/> 6,500 <hr/>

In this section the sequence seems to be conformable throughout, but westwards the overlap of several members causes unconformities in point of time, although the parallelism of the strata remains perfect. Beds Nos. 1 and 2 thin out E. and W. in the Barapahars, and it is possible that, from the calcareous character of No. 2, they belong rather to the upper Karnul series.

Nos. 3, 4, 5 and 6 are very constant throughout the whole of the hill country. The 7 and 8 bands thin out suddenly to the west of the Barapahars, but re-appear 15 miles to the west in a modified form. To the south-west in Phuljhar all the lower bands appear to be changed, and fine clay shales cover the Phuljhar plain. But this area has not yet been worked out. The No. 9 band is interesting. It occurs constantly, resting on the lower levels of the gneiss, from which it was directly derived, and with which it seems to be more closely connected than with the various beds which overlie it. It is composed of coarse felspathic grit, usually pale-green in colour, with frequent bands of sub-angular pebbles of white quartz. Pale-green porcellanic shales frequently overlie the grit. Bands of this rock are found here and there folded into the gneiss of the Sambalpur plain, and highly metamorphosed, so it is not improbable that it may represent a separate series, and correspond with the 'transitions.'

The general lie of the Cuddapah rocks is with gentle dips to the north, under the Mahanadi valley; but there are several considerable folds in them, resulting locally in faults, with a very constant N. and S. axis. The eastern boundary of the Barapahars is also an extremely disturbed one, the whole series being crushed against the gneiss, with a faulted junction.

The upper 'Karnul' series of limestones and purple shales overlies the Cuddapahs with slight unconformity. The stratification of the two is however parallel, and the Karnuls have shared in all the disturbances and folds which contort the Cuddapahs.

The Karnuls dip down gently northwards, over the Cuddapahs, and cover the whole of the Mahanadi valley plain, where the dip undulates gently. Exposures are rare on the plain, and only disconnected sections are seen in the larger ravines. The best exposures occur along the bed of the Mahanadi, but even there they are not continuous, and it is impossible to make out the detailed sequence of beds. There seems to be considerable lateral variation in constitution also. The topmost beds of the series have probably not been seen, but so far as at present observed, the following represents a rough section in descending order:—

1. White compact limestone . . . . .	200 feet.
2. Purple shales with grey laminæ . . . . .	500 „
3. Purplish limestone with discoidal concretionary markings . . . . .	150 „
4. Purple shales with grey-green siliceous laminæ, thin porcellanic shales and jasper . . . . .	1,200 „
5. Black and buff compact limestone with bands of dark shale and some coarse grit . . . . .	200 „
	<hr/> 2, 250

Several dykes of the compact dark-green trap occur both in the Karnuls and Cuddapahs, but I have found no trace of interbedded trap in either series.

*Trap.*

Thin caps of laterite occur all over the plains, overlying all kinds of rocks, and also amongst the hills. The laterite lying on the gneiss appears to be *in situ* and to be derived

*Laterite.*

directly from the rock beneath, into which it passes by insensible gradations.

Limestone and iron-ore are the only minerals of economic value I have met with. The Karnul No. 5 limestone is burnt extensively in Sarangarh for lime.

*Iron-ore.*

Many villages have their diminutive blast furnaces, but the *lohari's* make no use of the lateritic hæmatite, but prefer a soft porous clayey limonite, which appears to be concretionary, and occurs in the lower Cuddapah shales in small quantities.

I have not met with any diamonds or diamond mines, nor could I get any information of any ancient workings. The industry of washing for diamonds in the Mahanadi at

*No diamonds.*

Hirakoond also seems to have entirely died out.

## 8. Burma.

During the field season of 1896 to 1897 Mr. Grimes was engaged on the survey of parts of the districts of Magwe, Myingyan and Pokoku in upper Burma; the country surveyed

*G. E. Grimes.\**

\*As this report goes to press, the lamentable information has reached Calcutta that Mr. Grimes succumbed to an attack of cholera at Thayetmyo on the 11th April. Mr. Grimes has shown great zeal in his work and much ability during the 2½ years of his service, and I was looking forward to the time when he would develop into one of our best stratigraphical geologists. He was only 26 years of age when he died.

in detail is that comprising the Yenangyoung and Yenangyat oilfields, but besides this a considerable area to the east, of which there are no satisfactory maps, was explored.

The country consists of open plains from which a series of low ranges of hills rise, each being composed of and caused by an anticlinal fold, in the larger of which the miocene beds are exposed. These run roughly parallel with each other in a WNW—ESE direction, but are independent. The two largest and most important of these are the Yenangyat and Yenangyoung anticlines, both of which were examined in detail. The other lesser ones are those which form the Pagan and the Gwgyo hills, lie in the unsurveyed country to the east and were only cursorily examined.

The rocks exposed are everywhere the same as those described by Dr. Nøtling in his memoir on the occurrence of petroleum in Burma, and the only addition to be made to his description is the existence of an unconformity between the upper miocene (Yenangyoung stage) and the pliocene (Irrawadi river) beds which overlie them.

The most important economic results of the survey have been the mapping of the extension of the Yenangyat oilfield and the discovery of what are likely to be two new oilfields on the same anticline. The probable extent of the area over which petroleum may reasonably be expected to be workable is found to be some  $6\frac{1}{2}$  miles, or three miles to the south and  $3\frac{1}{2}$  miles to the north of Yenangyat. From the nature of the data and reasoning on which this estimate is based, it is more likely to be a minimum than a maximum. Besides this extension of the Yenangyat field, Mr. Grimes found another place where the axis of the anticline rises, and in block 58 N of the Yenangyoung oilfields survey there is a small exposure of the lower miocene (Promé stage); it is very probable that an oilfield, small perhaps but workable, will be found here.

To the north of Yenangyat a larger exposure of the beds of the Promé stage was found and here the first or uppermost oilsand is freely exposed at the surface; Mr. Grimes was informed by the villagers that the hill had been on fire last year where this oilsand is exposed and that it had burnt for several months with flames three feet high. The ground was blackened and showed signs of burning, so this statement may well be correct. It is probable that there is a larger and more prolific oilfield here than that of Yenangyat and not impossibly than Yenangyoung. The southern end of this may be placed in block B of the Yenangyat oilfields survey and the northern some 6 miles north of the limit of the survey.

In the Yenangyoung oilfield the exposure of miocene beds was found to widen out to the south of Dr. Nøtling's survey representing a slight rise of the axis of the anticline in blocks 33 and 45 and then to close in and finally disappear. It is possible that a boring put down here would strike oil, but the field would be a small one and probably not very productive.

In the Pagan and Gwegyo anticlines the lower miocene—petroliferous—beds are not exposed. In the Gwegyo hills some places were pointed out where it was said that oil had been seen at times. It is possible that in the future petroleum will be worked at both these localities, but the fact that both anticlines are faulted, conjoined with the absence of visible oil-springs, is not promising for a large supply of petroleum.

On his return from the field Mr. Grimes visited Akyab and examined the neighbourhood with a special view to the possibility of sinking an artesian well, the water-supply of the town being both scanty and inadequate. The town is built on recent deposits, and the only exposures of rock in the neighbourhood are along the crest of an antichnal, apparently the continuation of that which forms the Baronga island. In these circumstances it would be hopeless to look for a water supply from the tertiary rocks even if they could be reached, while neither the nature nor the disposition of the recent deposits is such as to lead to any anticipation of an artesian well of the deltaic type being met with.

Mr. Grimes was principally engaged during the last camping season in surveying the Kabwet coal field in detail, after which he proceeded to examine several smaller areas near Mandalay. He has sent in the following short reports:—

*The Kabwet Coal field.*—During the first two and-a-half months of the present (1897-98) camping season I was engaged in the examination of the Kabwet coalfield and the surrounding area between Kabwet and Male in the District of Shwebo, Upper Burma.

The rocks in this area are chiefly sandstones mostly soft and current bedded but sometimes calcareous in which case they are very hard. Almost everywhere the sandstones contain numerous rounded hard calcareous concretions, which weather along the original planes of bedding. Interstratified with the sandstones are some strings and thin beds of greyish or bluish shale which are quite subordinate to the sandstones and nowhere of any great thickness, and besides these there are at separate horizons a bed of contemporaneous basaltic lava, a bed of carbonaceous shale and coal and a thick mass of limestone.

Although all the sandstones have many characters in common and those in different parts of the area and at different horizons are often very difficult to distinguish from one another, besides recent alluvial beds four stages may be distinguished in the sandstones which can be identified and mapped with a fair degree of accuracy, and the following is a description of them and of the alluvial beds in descending order.

The alluvial beds, which are chiefly deposited in a narrow strip of country running from north to south across the area, consist chiefly of ordinary river sands with beds of mud and clay in places. Small calcareous concretions resembling kankar

are found in them in places but they are not widely distributed in the beds.

Of recent origin also are the greater part of the fragments of silicified wood which are everywhere thickly scattered over the surface of the ground in the area examined. This is called by the Burmans "ingyin kyauk" and they say that the fragments are pieces of the ingyin tree (the acacia ferruginea) which have been left lying on the ground and there silicified. In support of this local theory of the origin of the wood I have on several occasions noticed marks on the wood as if it had been cut by a "dah" and besides this there is the universal distribution of the silicified wood, mostly in angular fragments in every part of the area where the "ingyin" tree grows. All the silicified wood, however, is not of recent origin as will be shown later.

*1st Stage.*—(The uppermost) strata of the tertiary strata consist chiefly of yellowish and yellowish white current-bedded sandstones which are so soft as easily to crumble between the fingers. These contain small irregularly shaped calcareous concretions and usually have a network of calcareous strings and besides these, there are larger rounded calcareous concretions and layers of hard calcareous sandstone. With these sandstone beds there are often interstratified thin bands of greyish and bluish-grey shales and sandy shales, but these are quite subordinate and never of any great thickness. Conglomerate beds are found but are comparatively rare. Embedded in the sandstones and evidently of the same age there are pieces of siliceous fossil wood, like that which I have seen in other parts, and of this large tree trunks are to be seen in places. Lying in one of the stream beds, where it crosses the sandstones near the base of this stage there was a very large, rounded and polished boulder of granite, quite unlike any of the rocks which I know to occur in the surrounding country so that it must have come from a considerable distance, and as it is much too large to have been transported to its present position by any of the physical agencies, now at work, I concluded that it had come out of the beds on the top of which it is now resting.

*2nd Stage.*—The beds of the 1st stage pass conformably down into those of the 2nd stage, which consist chiefly of fairly soft yellowish, reddish-yellow and brownish sandstones mostly somewhat micaceous. They are as a rule somewhat harder than the beds of the 1st stage and more regularly bedded, and they also contain very numerous and often large greyish calcareous concretions, which are harder than those in the beds above, and besides these there are several thick layers of very hard calcareous sandstone, which latter is mostly conglomeratic. Interstratified with the sandstones are quite subsidiary bands of greyish and bluish-grey shale, mostly somewhat sandy and very similar to that of the 1st stage.

*3rd Stage.*—The beds of this stage also are almost entirely composed of sandstones, which vary, however, somewhat in appearance in the different

parts of this stage. The upper sandstones are white, bluish-white or yellow in colour and are usually very coarse and friable, whilst those in the lower part are greyish and yellowish and harder. Calcareous concretions and bands are present but are not so common as in the beds higher up and they are also chiefly confined to the lower beds of this stage. With the sandstones there are a few beds of soft shale and clay of blue or bluish-grey colour and the bed which lies just underneath the coal, in the southern part of the area is of a particularly bright blue colour. At one horizon in these beds and resting directly upon sandstone there is a bed of basic lava which is thickest and most prominent at Nat-taung, but it decreases in thickness as one gets away from that centre and gradually dies out. Lying on the top of the lava are indurated red-clays, which likewise die out to the north and east but extend to a short distance beyond the limits of the lava. At a horizon a little above the lava and red-clay there is a bed of carbonaceous shale or coal which extends over the whole of the area where the beds of this age are exposed and so much beyond the lava and red-clay. This bed varies very considerably in composition and thickness within a short distance, and it is doubtful if it is perfectly continuous over the whole area, as in one or two places where the beds of this horizon are fairly well exposed, I failed to find any traces of it; the exposures of it, however, are few in number, owing to the beds being for long distances overlaid by recent deposits and to the way in which the country was covered up at the time of my visit by jungle with long grass. With regard to the composition of this bed I can only now say, before the analysis of my samples, that judging from the appearance of the beds, the most westerly exposures between Letkokbin and Kabwet are the richest in carbon, and all the other exposures show an inferior coal or even only a brown carbonaceous shale with streaks of coal. Embedded in this carbonaceous shale and coal are numerous small pieces of amber.

*4th Stage.*—The beds of this stage consist also chiefly of massive greyish, whitish and yellowish sandstones, mostly coarse but sometimes fine-grained and in places argillaceous. Hard calcareous concretions and bands are common in them and the uppermost beds have a considerable resemblance to the sandstones of the 3rd stage. Interbedded with these sandstones are some brown shales which are typical of this stage and quite unlike the shales in the other stages. In the northern part of the area there is interstratified with these beds a thick mass of blue limestone which passes gradually into calcareous shale and so into the other beds of the series. This limestone is apparently unfossiliferous, as although I searched in it carefully, I could not find signs of a single fossil. Running through these rocks there are numerous dykes of dolerite which resembles in appearance the basic lava interstratified with the beds of the 3rd stage, but here it is evidently intrusive, as in several places it is to be seen breaking through and running across the bedding planes of the sandstones.

Coming now to the structure of the country, we find that the rocks are bent into a number of synclinal and anticlinal folds whose axes have an approximately north and south direction, and besides smaller faults the area is traversed from one end to the other by two large faults also running approximately north and south.

*Structure.*

The beds of the 1st and 2nd stages which are exposed in the western part of the area and bounded on the east by the more westerly of these two faults, are folded with generally quite low dip. The beds of the third stage lie between the two great faults mentioned above, and as the latter tend to converge towards the north, the area of these beds is narrower in the northern than in the southern part of the country examined. In the northern part of the area these beds are bent into a single anticlinal arch which sinks towards the north so that only beds younger than the coal are exposed to the north of the Khodaung Choung; but in the southern part where the breadth of the exposure of the beds of the third stage is greater, there are more foldings and the coal is worked in a small synclinal basin between Lethokbin and Kyetsubin which is bounded by the western fault. The greater part of the area between the faults is, however, covered up by recent deposits so that the folding of the beds beneath cannot always be seen.

The beds of the fourth stage, which are exposed in a narrow strip of country running along the Irrawadi and bounded to the west by the easternmost of the big faults, are everywhere steeply inclined and their dip is mostly vertical or almost so and when it is lower this is generally seen to be due to local contortions.

Of the exact age of these sandstone beds there is no direct evidence in the area examined, and one has to rely almost entirely on their lithological resemblance to beds of known age in other places. The beds of the first stage are in many respects like the pliocene sandstones, which I have examined in the Myingyan and Pokokku districts and like them they are current bedded soft sandstones containing silicified fossil-wood, so that I am inclined to think that the beds of the first stage are possibly of pliocene age also. The beds of the first stage rest quite conformably on those of the second stage, and I have sometimes doubted whether the latter ought to be separated from the first stage as they are in many respects alike, and besides the beds of the second stage are very unlike the upper miocene sandstones and gypsum bearing shales which underlie the pliocene farther south.

The beds of the third stage and those of the second stage are here separated by a fault, so that the relationship between them cannot be seen, but I think that the former are older than the latter, as they (the beds of 3rd stage) in many ways resemble the miocene beds of other places and are entirely unlike any post pliocene beds I have seen in Burma.

*Age of sandstones.*

The beds of the fourth stage are also separated from those of the third stage by a fault, but it is probable that this fault does not extend quite to the south of the area, and if not, the beds of the third stage are there resting on those of the fourth stage. Besides this, however, we have further evidence tending to show that the beds of the fourth stage are older than those of the third stage, in the fact that they are pierced by intrusive dykes of dolerite, which is exactly like that forming the bed of lava, which is interstratified with the beds of the third stage.

During the latter half of this present camping season (1897-98) I have been examining those parts of the Mandalay and Sagaing Districts which are mapped on sheets Nos. 260 and 261 (1"-1 mile) of the Upper Burma Survey. This area is divided by the river Irrawadi into two very unequal parts, the physical features of which are quite unlike, the larger and eastern part being the Mandalay plain and the smaller and western area the Sagaing hills. As I shall want to refer to the Sagaing hills when considering the rocks of the hills in the other area, I shall consider them first although they were not examined till last.

*Sagaing hills.*—The rocks in these hills consist chiefly of a series of crystalline limestones, quartzites and mica schists and resting unconformably on them coarse current bedded sandstones probably of pliocene age.

The first series, that of the metamorphic rocks, forms the main mass of the hills and all the highest ridges are formed of them.

*Crystalline rocks.*

The limestones of this series vary very considerably in the different parts of the hills and in the different beds, in the southern part of the hills they usually contain a lot of mica and other minerals included in them, whilst farther north near Mingun and Tonbo we find hills composed of an almost pure white crystalline limestone and these are the highest ridges in the range of hills. If we trace these limestones, however, along their strike to the north-west we find in the low hills on the west side of the range, blue limestones which are not crystalline and which are in appearance very like the limestones in the Shan hills to the east of Mandalay.

Interstratified with the limestones but usually in very thick beds are quartz and mica schists, in which rocks the mica is often concentrated in definite layers so that the rock consists of alternate layers of quartzite and mica schist; in other places, however, where the rocks contain more mica the whole is a mica schist. On the western side of the hills in the same relation to these quartzites and mica schists, as the blue limestone is to the crystalline limestone, we find coarse dark reddish brown ferruginous and often micaceous sandstones.<sup>1</sup>

<sup>1</sup>In a note which Mr. Grimes sent a few days before his death, he announces the fact that this sandstone has yielded plant remains. This is an important discovery, and it is to be hoped that more details may be forthcoming when his diaries and collections reach Calcutta.

Of the age of these rocks there is no definite evidence, and the only indication we have is the likeness of the blue limestone to that in the Shan Hills east of Mandalay, which Dr. Noetting on the evidence of some fossils obtained by him, regards as lower silurian or even older.

*Age of rocks.* Resting unconformably on the upturned edges of these older and metamorphosed rocks a series of soft white, yellowish-white and brown current bedded soft sandstones, mostly pebbly and especially in the northern part of the hills often conglomeratic. In these are dark reddish brown ferruginous strings and layers and rounded calcareous concretions. These beds are exactly like the pliocene beds in the Myingyan district and perhaps two specimens of fossil teeth which I have obtained from these beds may enable the question of their age to be definitely settled.

*Tertiary rocks.* The older metamorphosed rocks, the plains of foliation of which correspond with the original planes of bedding, have in the southern part of the hills everywhere a steep dip, but at the northern end of the range this decreases somewhat. The dip is everywhere to the east with the exception of the eastern side of the southern end of the hills where it is a steep westerly one.

The newer, probably pliocene, beds rest on the upturned edges of the older beds and are also dipping to the east, but with low angles under  $20^{\circ}$ . These beds are chiefly exposed on the eastern side of the hills, starting from near Wachuset and extending towards the north, at first their exposures are not very elevated above the Irrawadi, but as one goes north one sees them forming higher and higher hills and extending farther and farther west, until at the northern end of the range they have completely covered up the older beds and the hills are formed by them alone. This area consists of a large flat plain, extending for many miles around Mandalay out of which a number of isolated hills arise and the rocks may be divided into two series, the one consisting of the metamorphosed and crystalline rocks of the isolated hills and the other the alluvial beds of the plain.

*Mandalay plain.* The rocks composing the hills vary very greatly in character, so that almost every hill is composed of a different rock, but they are all highly metamorphosed and mostly crystalline. The chief rocks are crystalline limestone and quartzite, the first forming the hills near to and to the east of Mandalay, and the latter being most prominent in those farther north. Mandalay hill is composed of a white crystalline limestone containing mica and other minerals, but at Yangintaung which is nearer the Shan hills the limestone is greyish and not so highly metamorphosed and it is much more like the rocks exposed on the western

*Description of rocks.*

slopes of these hills. Five miles to the north, however, in the group of hills south-east of Lundaung, we meet with entirely different kinds of rock and here Gondama Taung and the hills to the south of it are composed almost entirely of quartzite, which is however, mostly somewhat micaceous and calcareous, but Shwe Young Daung to the west of these is formed chiefly of mica schists, with which are associated some crystalline rocks. Only a mile to the east of Gondama Taung, the beds of which are dipping to the east, in the low hills on the north side of Kangyi village, we find an exposure of coarse granite and at Sagadaung about two miles to the north of Gondama Taung we have greyish-white gneiss. The other hills, which I have examined to the north and east of these are all composed of quartzites and micaceous schists.

Owing to the isolated nature of the exposure of these rocks and also to the fact that definite dips and strikes cannot always be seen in them, it is impossible from an examination of these hills alone to determine the relation of the different rocks to one another, and in order to ascertain this certainly it will be necessary first to examine the hill country around. The rocks in the isolated hills are apparently outliers of those in the Shan hills as an examination of the western slopes of those hills at different places showed similar rocks to those in the isolated hills, especially to those close to them. In some cases, however, as for instance Mandalay hill, the rocks of the hills in the plain are quite different from any I have seen in the Shan hills, but in these cases they show crystalline structure highly developed, and the difference is most probably due to the metamorphic changes which have evidently taken place in them. The white crystalline limestone of Mandalay hill is certainly very unlike the blue limestone of the hills to the east, but a similar difference and change can be seen in the Sagaing hills, when the limestone is traced along its strike from one side of the hills to the other, so that in this case too the difference is probably due to metamorphism.

The granite and possibly the gneiss are in all probability intrusive, but whether the other rocks all belong to one system is still an open question. In the Sagaing hills we see similar rocks interstratified with one another, but an examination of the Shan hills between Tonbo and Maymyo showed practically nothing but limestone, and until the relation of this limestone to the quartzitic and schistose rocks of the same hills farther north is established, the stratigraphical connection between the outliers of these rocks cannot be determined.

The whole of the plain from which these isolated hills rise is covered by alluvial beds, which present an uniformly flat surface, so that but little can be seen of them. On the top, especially in the eastern part of the plain they seem to consist chiefly of mud, silt and fine grained sand and deeper down the wells show coarser sand, but where the Irrawadi crosses the plain the sections shewn in the banks of the river are all coarse sand.

## 9. North-West Frontier.

The military operations across the Afridi border of the North-Western Frontier under the Command of General Sir W. S. A. Mr. H. H. Hayden. Lockhart, K.C.B., K.C.S.I., offered an opportunity of adding to our knowledge of the geological structure of that country. In October 1897, Mr. Hayden received permission to accompany the Tirah Expeditionary Force and was absent on that duty till January 3rd, 1898. At various times I have traversed parts of the country myself, so for instance when accompanying the Miranzai field force in 1890 to 1891, and during several trips through the Khaibar and Kabul valleys. Some of the results are embodied in my paper on the Safed Koh, published in the Records, Vol. XXV, pp. 59, ff., but the information gained was necessarily sketchy and in parts speculative, but it is satisfactory even to find that Mr. Hayden's work last season has resulted in establishing the truth of one supposition, namely, that palæozoic and triassic rocks make their appearance along a great east to west dislocation, which separates the main mass of the Safed Koh range from the "outer" hills lying south of it.

The following is a brief summary of the results of Mr. Hayden's work :—

The country between the Samana range and the Khaibar consists of a series of parallel mountain-ranges, running east to west. The rocks, which are chiefly of mesozoic age are folded into numerous anticlines and synclines with many inverted folds and faults. South of the Bara valley no rocks older than mesozoic are found, but along the southern flank of the Surghar range these beds are faulted against strata of palæozoic age.

The following is a broad sub-division of the rocks in descending order :—

- |   |   |                      |
|---|---|----------------------|
| 10. Light-coloured limestone with nummulites (Kohat, Ustarzai, Hangu, etc.)                           | } | Upper eocene.        |
| 9. Green and red shales and sandstones (Kai and Waran Valley.)  |   | Lower eocene.        |
| 7. Grey limestones, with sandstones . . . . . and   | } | cretaceous and       |
| 8. Shaley limestones and subordinate shales . . . . .   |   | jurassic.            |
| 6. Massive coral limestone (Gorge between Bagh and Dwatowi)   | } | rhaetic.             |
| 5. Red gritty shales, grits, conglomerates and reddish-brown needle shales (Bara and Bazar valleys).  |   | trias.               |
| 4. Limestone and calcareous sandstone, with middle Productus limestone fossils.                       | } | permian.             |
| 3. Greenish-brown shales, with flaggy quartzites and subordinate limestone bands (Chura and Khaibar). |   | permo-carboniferous. |
| 2. Altered limestones of Rohtas hill, Ghund Ghar and Surghar range.                                   | } | carboniferous.       |
|   |   |                      |

1. Hard slates and white quartzites of Surghar range (near Sher Khel in Bara valley.) } order  
palaeozoic.

Owing to paucity of fossils much of the above classification is merely tentative, but eocene fossils were found in Maidan and cenomanian brachiopods in the Waran valley, while between Chura and the Bazar valley are beds containing species found in the middle productus limestone of the Salt range.

No igneous rocks are found *in situ* south of the Surghar range, but they probably occur a little further west on the southern flanks of the Safed Koh. In the Khaibar a decomposed dolerite is found among the carboniferous rocks, and in the stream-beds many boulders of altered gabbro.

## Appendix I.

*List of Societies and other Institutions from which publications have been received in donation or exchange for the Library of the Geological Survey of India, from the 1st January 1897 to the 31st March 1898.*

- ADELAIDE.—Geological Survey of South Australia.  
 „ Royal Society of South Australia.  
 ALBANY.—New York State Museum.  
 BALTIMORE.—Johns Hopkins University.  
 BASEL.—Naturforschende Gesellschaft.  
 BATAVIA.—Kon. Natuurkundige Vereeniging in Ned.-Indie.  
 BERKELEY.—University of California.  
 BELFAST.—Natural History and Philosophical Society.  
 BERLIN.—Deutsche Geologische Gesellschaft.  
 „ K. Preuss. Akad. der Wissenschaften.  
 „ K. Preuss. Geologische Landesanstalt.  
 BOLOGNA.—R. Accad. delle Scienze dell' Istituto di Bologna.  
 BOMBAY.—Natural History Society.  
 „ Royal Asiatic Society.  
 BORDEAUX.—Société Linnéenne de Bordeaux.  
 BOSTON.—American Academy of Arts and Sciences.  
 „ Society of Natural History.  
 Breslau.—Schlesische Gesellschaft für Vaterländische Cultur.  
 BRISBANE.—Queensland Branch of the Roy. Geog. Soc. of Australia.  
 „ Queensland Museum.  
 „ Royal Society of Queensland.  
 BRISTOL.—Naturalists' Society.  
 BRUSSELS.—Société Royale Belge de Géographie.  
 BUCHAREST.—Museul de Geologia si de Paleontologia.  
 „ Geological Bureau.  
 BUDAPEST.—Kön. Ungarische Geologische Anstalt.  
 „ Ungarische Geologische Gesellschaft.  
 „ National Museum.  
 BUENOS AIRES.—Acad. Nacional de Ciencias.  
 „ Museo Nacional.  
 CAEN.—Société Linnéenne de Normandie.  
 CALCUTTA.—Agricultural and Horticultural Society of India.  
 „ Asiatic Society of Bengal.  
 „ Calcutta University.  
 „ Editor, Indian and Eastern Engineer.  
 CAMBRIDGE.—Philosophical Society.  
 „ University of Cambridge.  
 „ Woodwardian Museum.

- CAMBRIDGE, MASS.—Museum of Comparative Zoölogy.  
 CANADA.—Hamilton Association.  
 CAPE TOWN.—South African Geological Commission.  
 CASSEL.—Vereins für Naturkunde.  
 CHRISTIANA.—The Committee, Norwegian North-Atlantic Expedition.  
 CINCINNATI.—Society of Natural History.  
 COPENHAGEN.—Kong. Danske Videnskabernes Selskab.  
 " Academie Royale des Sciences et des Lettres.  
 DES MOINES.—Iowa Geological Survey.  
 DIJON.—Academie des Sciences et Belles-Lettres.  
 DRESDEN.—K. Min. Geol. und Præhistorische Museum.  
 " Naturwissenschaftliche Gesells. Isis.  
 DUBLIN.—Royal Dublin Society.  
 " " Irish Academy.  
 EDINBURGH.—Royal Scottish Geographical Society.  
 " " " Society of Arts.  
 GENEVA.—Societe de Physique et d'Histoire Naturelle.  
 GLASGOW.—Glasgow University.  
 " Philosophical Society.  
 GOTHA.—Editor, Petermann's Geog. Mittheilungen.  
 GÖTTINGEN.—K. Gesells. der Wissenschaften.  
 HALIFAX.—Nova Scotian Institute of Science.  
 HALLE.—Academia Cæsarea Leop. Carol. Nat. Curiosorum.  
 HELSINGFORS.—Société de Géographie de Finlande.  
 KÖNIGSBERG.—Physikalische Ökonomische Gesellschaft.  
 LA PLATA.—Museo de La Plata.  
 LAUSANNE.—Société Vaudoise des Sciences Naturelles.  
 LAWRENCE.—Kansas Geological Survey.  
 " " University.  
 LEEDS.—Yorkshire College.  
 LEIDE.—Ecole Polytechnique de Delft.  
 LEIPZIG.—Kön. Säch. Gesells. der Wissenschaften.  
 " Vereins für Erdkunde.  
 LIÉGE.—Société Geol. de Belgique.  
 LILLE.—Société Geol. du Nord.  
 LISBON.—Section des Travaux Geol. du Portugal.  
 LIVERPOOL.—Geological Society.  
 " Literary and Philosophical Society.  
 LONDON.—British Museum (Natural History).  
 " Geological Society.  
 " Geological Survey of the United Kingdom.  
 " Iron and Steel Institute.  
 " Linnean Society of London.  
 " Royal Geographical Society.  
 " " Institution of Great Britain.  
 " " Society.  
 " Society of Arts.

- LONDON.—Zoölogical Society.  
MADRID.—Real Academia de Ciencias Exactas Físicas y Naturales.  
„ Sociedad Geographica de Madrid.  
MAINE.—Portland Society of Natural History.  
MANCHESTER.—Geological Society.  
„ Literary and Philosophical Society.  
MARSEILLES.—Faculty des Sciences.  
MELBOURNE.—Australasian Institute of Mining Engineers.  
„ Dept. of Mines and Water Supply, Victoria.  
„ Royal Society of Victoria.  
MEXICO.—Instituto Geológico de Mexico.  
MILAN.—Società Italiana di Scienze Naturali.  
MINNEAPOLIS.—Minnesota Academy of Natural Sciences.  
MOSCOW.—Société Imp. des Naturalistes.  
MUNICH.—Kon. Bayerische Akad. der Wissens.  
NAPLES.—Reale Acad. delle Scienze Fisiche e Matematiche.  
NEWCASTLE-UPON-TYNE.—North of England Institute of Mining and Mechanical Engineers.  
NEW HAVEN.—Editor, American Journal of Science.  
NEW YORK.—Academy of Science.  
„ Geological Survey.  
OTTAWA.—Geological and Natural History Survey of Canada.  
„ Royal Society of Canada.  
OXFORD.—University Museum.  
PARIS.—Comptoir Geologique de Paris.  
„ Department of Mines.  
„ Editor, Annuaire Geologique Universel.  
„ Ministère des Travaux Publics.  
„ Museum d'Histoire Naturelle.  
„ Société de Géographie.  
„ „ Geologique de France.  
PENZANCE.—Royal Geological Society of Cornwall.  
PERTH.—Dept. of Mines, Western Australia.  
PHILADELPHIA.—Academy of Natural Sciences.  
„ American Philosophical Society.  
„ Franklin Institute.  
PISA.—Società Toscana di Scienze Naturali.  
RIO-DE-JANEIRO.—Imperial Observatory.  
ROCHESTER.—Geological Society of America.  
ROME.—Reale Accad. dei Lincei.  
„ Reale Comitato Geologico d'Italia.  
„ Società Geologica Italiana.  
SALEM.—American Assoc. for the Advancement of Science.  
„ Essex Institute.  
SAN FRANCISCO.—California Academy of Sciences.  
SINGAPORE.—Straits Branch of the Royal Asiatic Society.

- SPRINGFIELD.—Illinois State Museum of Natural History.  
 STOCKHOLM.—Kon. Svenska Vetenskaps Akademi.  
 ST. PETERSBURG.—Academie Imperiale des Sciences.  
     "    Comite Geologique.  
     "    Musée Geol. de l'universite Imperiale.  
     "    Russ. Kaiser. Mineralogische Gesells.  
 SYDNEY.—Australian Museum.  
     "    Dept. of Mines and Agric., N. S. Wales.  
     "    Geological Survey, " "  
     "    Linnean Society, " "  
     "    Royal " " "  
 TOKIO.—Deutsche Gesells. für Natur. und Volkerkunde.  
     "    Imperial University of Japan.  
 TORONTO.—Canadian Institute.  
 TURIN.—Osservatorio della R. Universita.  
     "    Reale Accad. delle Scienze.  
 UPSALA.—Upsala University.  
 VENICE.—Reale Istituto Veneto di Scienze.  
 VIENNA.—K. Akad. der Wissenschaften.  
     "    K. K. Geog. Gesellschaft.  
     "    K. K. Geol. Reichsanstalt.  
     "    K. K. Naturhistorischen Hofmuseum.  
 WARSAW.—Inst. Agronomique et Forestier.  
 WASHINGTON.—Philosophical Society.  
     "    Smithsonian Institution.  
     "    U. S. Dept. of Agriculture.  
     "    "    Geological Survey.  
     "    "    National Museum.  
 WELLINGTON.—Geological Survey, New Zealand.  
     "    Mining Dept., "  
     "    New Zealand Institute.  
 YORK.—Yorkshire Philosophical Society.  
 ZÜRICH.—Naturforschende Gesellschaft.  
 The Governments of Bengal, Bombay, Burma, India, Madras, the North-  
 Western Provinces and Oudh, and the Punjab.  
 The Chief Commissioners of Assam, Central Provinces and Coorg.  
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**Appendix II.**

**THE INSPECTOR OF MINES IN INDIA.**

This officer being under my administrative control, I have to report that Mr. James Grundy. during the period from the 1st January 1897 to the 31st March 1898, his duties consisted of a large number of inspections of coal and mica mines, which entailed a considerable amount of office work as is shown in the Annual Report of the Inspector of Mines for 1896 which was printed during the autumn of 1897. I returned too late from furlough to enable me to make such alterations in this publication as appeared to me desirable.

Mr. Grundy was absent on privilege leave from the 12th October 1897 to the 13th January 1898.

CALCUTTA ;  
The 1st April 1898. }

C. L. GRIESBACH,  
*Director, Geological Survey of India.*





